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(54) Patent Title: Semiconductor raw material ingot support jig and seed crystal and single crystal production method using same

(57) [Abstract] (Revisions included)

[Purpose] To provide a semiconductor raw material ingot support jig and seed crystal, and a single crystal production method that uses them, that can completely melt the semiconductor raw material ingot without leaving any unmelted part, and further, which does not contamination of the inside of the semiconductor single crystal production apparatus when supplying the semiconductor raw material ingot, which provides for improved single crystal

growth yield, and which does not increase the cycle time required for each pulling operation.

[Means of Solution] A semiconductor raw material ingot support jig that possesses a mounting member 11, in which a pulling wire 9 is mounted to its upper end 11a and a seed crystal S is mounted to its lower end, a support member 12, which is disposed on said mounting member 11 and supports a semiconductor raw material ingot M, and an operation control means 13 that is made from a semiconductor, and which releases the support state between the support means 12 and the semiconductor raw material ingot M, wherein, as the semiconductor raw material ingot M is melted, the aforementioned operation control means 13 is melted, whereby support of the semiconductor raw material ingot M by the support means 12 is released and the semiconductor raw material ingot M drops into the vessel 6 and is melted.

[FIGURE]

- Legend -

1 Single crystal production apparatus
2 Oven component chamber
3 Single crystal container
4 Heater
6 Quartz vessel
10 Semiconductor raw material ingot support jig
11 Mounting member
13 Operation control means
M Raw semiconductor ingot (silicon polycrystal ingot)
S Seed crystal

[Scope of the Patent Claim]

[Claim 1] A semiconductor raw material ingot support jig that is characterized by possessing a mounting member, in which a pulling wire is mounted to its upper end and a seed crystal is mounted to its lower end, a support means, which is disposed on said mounting member and supports a semiconductor raw material ingot, and an operation control means that is made from a semiconductor, and which releases the support state between the support means and the semiconductor raw material ingot, wherein, as the semiconductor raw material ingot is melted, the aforementioned operation control means is

melted, whereby support of the semiconductor raw material ingot by the support means is released and the semiconductor raw material ingot drops into the vessel and is melted.

[Claim 2] The semiconductor raw material ingot support jig described in Claim 1, which is characterized by the aforementioned support means being formed with multiple support bodies that are disposed on the mounting member so that they can open and close, and which support the semiconductor raw material ingot by pinching it by means of their opening or closing.

[Claim 3] The semiconductor raw material ingot support jig described in Claim 1 or 2, which is characterized by the aforementioned support means being disposed on the mounting member so that it can open and close, by the seed crystal being enclosed by the support bodies while the semiconductor raw material ingot is being supported, and by the seed crystal being exposed with the semiconductor raw material ingot drops into the vessel and is melted.

[Claim 4] The semiconductor raw material ingot support jig described in Claim 2 or 3, which is characterized by the aforementioned support bodies each being comprised with a pawl disposed at one end, and a weight mounted at the other end, of a support member, and with said support member mounted at its middle on a shaft disposed on the mounting member so that it can rotate freely.

[Claim 5] The semiconductor raw material ingot support jig described in any of Claims 1 through 4, which is characterized by the aforementioned support bodies being mounted on said shafts at an eccentric midpoint so that the activated weights on the support members are stationary at a position above the seed crystal.

[Claim 6] The semiconductor raw material ingot support jig described in any of Claims 1 through 5, which is characterized by the aforementioned pawls engaging into a support groove disposed on the side surface of the semiconductor raw material ingot.

[Claim 7] The semiconductor raw material ingot support jig described in any of Claims 1 through 6, which is characterized by the aforementioned operation control means being formed of a drop notch that is cut into the top of the

semiconductor raw material ingot, cutting across its cross section, to a depth that is deeper than the position of the support groove.

[Claim 8] The semiconductor raw material ingot support jig described in Claim 7, which is characterized by the aforementioned drop notch having a V-shaped or square sectional profile.

[Claim 9] The semiconductor raw material ingot support jig described in any of Claims 2 through 8, which is characterized by the aforementioned operation control means being a solid semiconductor polycrystal or single crystal that is disposed extending between connectors that are disposed on the support members, and by being contained inside a notch that is cut across the cross section and to a depth that is deeper than the position of the support groove.

[Claim 10] The semiconductor raw material ingot support jig described in Claim 1, which is characterized by the aforementioned support means being formed on the mounting member, being formed of support parts that link with connectors that are disposed in the semiconductor raw material ingot, which support parts are each formed in a fan-shape, with a gradually increasing sectional surface area, by the aforementioned operation control means being formed of a notch that is disposed cutting across the sectional surface at the top of the semiconductor raw material ingot, with the aforementioned seed crystal enclosed within the operation control means, wherein, as the semiconductor raw material ingot is melted, the semiconductor raw material ingot is split by the semiconductor raw material ingot melting, and the semiconductor raw material ingot drops into the vessel and melts.

[Claim 11] The semiconductor raw material ingot support jig described in Claim 10, which is characterized by the aforementioned support part possessing a spherical part.

[Claim 12] The semiconductor raw material ingot support jig described in Claim 11, which is characterized by the aforementioned support part comprising a conical part.

[Claim 13] The semiconductor raw material ingot support jig described in Claim 11, which is characterized by the spherical part of the aforementioned support part splitting away from the mounting member.

[Claim 14] The semiconductor raw material ingot support jig described in Claim 11, which is characterized by the conical part of the aforementioned support part splitting away from the mounting member.

[Claim 15] A seed crystal that is characterized by being enclosed inside an enclosure disposed in the semiconductor raw material ingot, by being equipped with a single crystal growth part that grows a single crystal when placed in contact with the semiconductor raw material melt and a fan-shaped support part with a gradually increasing sectional surface area that is disposed above said single crystal growth part, by said support part being fitted into the operation control means, which is disposed in the semiconductor raw material ingot and splits due to the semiconductor raw material ingot melting, so that, as the semiconductor raw material ingot is being melted, the semiconductor raw material ingot splits due to the semiconductor raw material ingot being melted, and the semiconductor raw material ingot drops into the vessel and melts, and also exposing the seed crystal growth part.

[Claim 16] The seed crystal described in Claim 15, which is characterized by the aforementioned support part possessing a spherical part.

[Claim 17] The seed crystal described in Claim 15, which is characterized by the aforementioned support part possessing a conical part.

[Claim 18] The seed crystal described in any of claims 15 through 17, which is characterized by the aforementioned support part being separated into multiple parts.

[Claim 19] A semiconductor single crystal production method in which a seed crystal that is mounted on a pulling wire is brought into contact with a semiconductor raw material melt contained in a vessel, and a semiconductor single crystal is grown from the seed crystal, wherein which semiconductor single crystal production method is characterized by possessing a process in which a semiconductor raw material ingot is supported by a semiconductor raw material ingot support jig that possesses a mounting member, in which a pulling wire is mounted to its upper end and a seed crystal is mounted to its lower end, a support means, which is disposed on said mounting member and supports a semiconductor raw material ingot, and an operation control means

that is made from a semiconductor, and which releases the support state between the support means and the semiconductor raw material ingot, a process in which, as said semiconductor raw material ingot is being melted, its linked state with the support means is released by the melting of the operation control means, and it drops and is melted, and a process in which the aforementioned seed crystal is brought into contact with semiconductor raw material melt inside the aforementioned vessel and a single crystal is grown.

[Claim 20] The semiconductor single crystal production method described in Claim 19, which is characterized by possessing a process in which a semiconductor melt is placed in advance inside the vessel as a pre-process preceding the process in which the semiconductor raw material ingot, supported by the aforementioned semiconductor raw material ingot support jig, is melted.

[Claim 21] The semiconductor single crystal production method described in Claim 20, which is characterized by the aforementioned process in which a semiconductor melt is placed in advance inside the vessel is a process in which semiconductor raw material is melted inside the vessel the in initial stage of semiconductor single crystal production.

[Claim 22] The semiconductor single crystal production method described in Claim 19, which is characterized by the aforementioned process in which a semiconductor melt is placed inside the vessel in advance is a process in which the semiconductor raw material melt from the previous performed semiconductor single crystal production is left in the vessel.

[Detailed Description of the Invention]

[0001]

[Field of Industrial Application] This invention pertains to a semiconductor raw material ingot support jig and a seed crystal, and to a single crystal production method that uses them, and in particular pertains to a semiconductor raw material ingot support jig and a seed crystal, and single crystal production method that uses them, that improve the method of supplying semiconductor raw material and provides for improved single crystal growth yield.

[0002]

[Prior Art] Semiconductor wafer production methods generally use a semiconductor single crystal production method in which a semiconductor single crystal is grown from a seed crystal by melting polycrystalline semiconductor raw material, and then bringing a seed crystal, which is made from a single crystal, into contact with said raw material melt.

[0003] For example, a method for producing silicon single crystal ingots by Czochralski's method (hereinafter, referred to as the CZ method) consists, as shown in Figure 24, of filling a quartz crucible 93, which is situated inside the oven component chamber 92 of a single crystal production apparatus 91, with silicon polycrystal raw material m_0 in the form of irregularly shaped chunks, and after then heating and completely melting the silicon polycrystal m_0 with a heater 94 that is situated around the outside of the quartz crucible 93, dipping a seed crystal S_0 that is mounted on a seed chuck 95 into the silicon melt and pulling the seed crystal S_0, while rotating the seed crystal S_0 and the quartz crucible 93 in opposite directions from each other, to grow a silicon single crystal Ig_0.

[0004] Since the raw silicon polycrystal material commonly used is in the form of irregularly shaped chunks, the chunks of silicon polycrystal m_0 that fill the quartz crucible 93 are heaped up, as shown in Figure 24, making it difficult to fill the quartz crucible with a large quantity at one time. In addition, an expensive new quartz crucible 93 must be used each time a single crystal is pulled, increasing the pulling cost.

[0005] Therefore, a so-called raw material replenishing system, like that shown in Figure 25, has been proposed as a measure to reduce costs. In this raw material replenishing system, a gate valve 102 can be used to separate the single crystal production apparatus 101 into the oven component chamber 103 and the single crystal chamber 104 when necessary, so that, with the gate valve open 102, the quartz crucible 105 situated inside the oven component chamber 103 is filled at the beginning of the single crystal pulling operation with silicon polycrystal chunks m_0. Separate from these silicon polycrystal chunks m_0, a silicon ingot M_0 is supported by wrapping a mounting wire 106 in a support groove 111 disposed in said silicon ingot M_0 and tying said mounting

wire 106 to, and supporting it on, a pulling wire 107 (Figure 25(a)), and then the silicon polycrystal chunks m_0 are melted to fill the quartz crucible 105 approximately 80% with silicon melt L_0 (Figure 25(b)), after which, pulling wire 107 is lowered separate from the silicon melt L_0, bringing the silicon ingot M_0 into contact with the silicon melt L_0 whereby it is melted and added to it (Figure 25(c)), causing the silicon melt L_0 to nearly entirely fill the quartz crucible 105.

[0006] Meanwhile, after the silicon polycrystal ingot M_0 has been melted, leaving an unmelted portion supported by the mounting wire 106, the mounting wire 106 is raised, the gate valve 102 is completely closed, the mounting wire 106, which is supporting the remainder of the silicon ingot, is replaced with a seed crystal support means 108 inside the single crystal chamber 104, which has now been isolated by the gate valve 102, and a seed crystal S_0 is mounted in said seed crystal support means 108 (Figure 25(d)).

[0007] After this, the gate valve 102 is opened and the seed crystal S_0 is brought into contact with the molten silicon melt L_0 in the quartz crucible 105 and a single crystal Ig_0 with the same crystal orientation as the seed crystal S_0 is grown below the seed crystal S_0 (Figure 25(e)), whereby the silicon melt L_0 inside the quartz crucible 105 is nearly depleted (Figure 25(f)).

[0008] With the semiconductor single crystal production method using the aforementioned single crystal production apparatus 101, the quantity of silicon single crystal produced per quartz crucible is increased over that of common CZ production methods, like that shown in Figure 24.

[0009] However, in this production method, the gate valve 102 must be closed at least once while the heater 109, etc. is on during operation of the single crystal production apparatus 101 to separate the oven component chamber 103 from the single crystal chamber 104. At this time the single crystal chamber 104 must be opened and the mounting wire 106, which is supporting the unmelted portion of the polysilicon ingot M_0, must be replaced with a seed crystal support means 108, the mounting wire 106, supporting the polysilicon ingot M_0, must be mounted on the pulling wire 107, and a seed crystal S_0 must

be mounted on the seed crystal support means 108, exposing the single crystal chamber 104 to the atmosphere. When the single crystal chamber 104 is reconnected to the oven component chamber 103 after being exposed to the atmosphere, dust drops down from the single crystal chamber 104, which hinders growth of the single crystal Ig_0 and is a major factor in decreased single crystal yields (the percentage of single crystal obtained without any crystal defects). In addition, dust, etc. is also dropped from the gate valve chamber 110 due to opening and closing of the gate valve 102. Furthermore, leaving an unmelted portion of silicon ingot on the mounting wire is uneconomical.

[0010] A raw material recharging system, as shown in Figure 26, has also been proposed as a cost reducing measure.

[0011] In this recharging system, a gate valve 122 can be used to separate the single crystal production apparatus 121 into an oven component chamber 123 and a single crystal chamber 124, so that, with the gate valve open 122, a single crystal Ig_1 is pulled up and removed, leaving molten silicon L_1 in the quartz crucible 125 situated in the oven component chamber 123 (Figure 26(a)), after which, inside the single crystal chamber 124, now isolated by the gate valve 122, the seed crystal support means 126 is replaced with a mounting wire 128, which is wrapped into a support groove 127 disposed in a silicon ingot M_1, which is mounted on a pulling wire 129 (Figure 26(b)), the polycrystal silicon ingot M_1, mounted on this mounting wire 128, is lowered into the silicon melt L_1, whereby it is melted into the silicon melt L_1 (Figure 26(c)).

[0012] While the quartz crucible 125 is nearly entirely filled with the silicon melt L_1 by melting the polycrystal silicon ingot M_1, the mounting wire 128, which is now supporting the remainder of the polycrystal silicon ingot M_1, is raised, the gate valve 122 is closed and, inside the single crystal chamber 124, now isolated by the gate valve 122, the mounting wire 128, supporting the remainder of the polycrystal silicon ingot M_1, is replaced with seed crystal support means 126 and a seed crystal S_1 is mounted on said seed crystal support means 126 (Figure 26(d)).

[0013] The gate valve 122 is then opened, the seed crystal S_1 is brought into contact with the molten polycrystal silicon M1 in the quartz crucible 125, and a single crystal Ig_1 is caused to grow on the seed crystal S_1 (Figure 26(e)).

[0014] However, in this production method, the gate valve 122 must be closed at least twice while the heater 130, etc. is on during operation of the single crystal production apparatus 121 to separate the oven component chamber 123 from the single crystal chamber 124. At this time the single crystal chamber 124 must be opened and the mounting wire 128, now supporting the unmelted remainder of the polycrystal silicon ingot M_1, must be replaced with a seed crystal support means 126, or conversely the seed crystal support means 126 must be replaced with a mounting wire 128 supporting a new silicon ingot M_1, twice exposing the single crystal chamber 124 to the atmosphere.

[0015] Consequently, the oven component chamber 123 is even further contaminated by dust, etc. in this recharging system than the replenishing system, which hinders growth of the single crystal Ig_0 and is a major factor in decreased single crystallization yields.

[0016] Furthermore, since gas must be replaced inside the pulling apparatus in both the replenishing and recharging systems described above, these also have the problem of requiring longer cycle times for a single pulling operation than the normal CZ method.

[0017]

[Problems to be Solved by the Invention] Therefore, there is a demand for a polysilicon raw material support jig and seed crystal, and a single crystal production method that uses them, which can completely melt the semiconductor raw material ingot without leaving any unmelted part, and further, which does not contamination of the inside of the semiconductor single crystal production apparatus when supplying the semiconductor raw material ingot, which provides for improved single crystal growth yield, and which does not increase the cycle time required for each pulling operation.

[0018] Taking the circumstances described above into consideration, the purpose of this invention is to provide a polysilicon raw material support jig

and seed crystal, and a single crystal production method that uses them, which can completely melt the semiconductor raw material ingot without leaving any unmelted part, and further, which does not contamination of the inside of the semiconductor single crystal production apparatus when supplying the semiconductor raw material ingot, which provides for improved single crystal growth yield, and which does not increase the cycle time required for each pulling operation.

[0019]

[Means of Solving the Problems] The gist of the invention of Claim 1 of this application, created to achieve the aforementioned purpose, is a semiconductor raw material ingot support jig that is characterized by possessing a mounting member, in which a pulling wire is mounted to its upper end and a seed crystal is mounted to its lower end, a support means, which is disposed on said mounting member and supports a semiconductor raw material ingot, and an operation control means that is made from a semiconductor, and which releases the support state between the support means and the semiconductor raw material ingot, wherein, as the semiconductor raw material ingot is melted, the aforementioned operation control means is melted, whereby support of the semiconductor raw material ingot by the support means is released and the semiconductor raw material ingot drops into the vessel and is melted.

[0020] The gist of the invention of Claim 2 of this application is the semiconductor raw material ingot support jig described in Claim 1, which is characterized by the aforementioned support means being formed with multiple support bodies that are disposed on the mounting member so that they can open and close, and which support the semiconductor raw material ingot by pinching it by means of their opening or closing.

[0021] The gist of the invention of Claim 3 of this application is the semiconductor raw material ingot support jig described in Claim 1 or 2, which is characterized by the aforementioned support means being disposed on the mounting member so that it can open and close, by the seed crystal being enclosed by the support bodies while the semiconductor raw material ingot is

being supported, and by the seed crystal being exposed with the semiconductor raw material ingot drops into the vessel and is melted.

[0022] The gist of the invention of Claim 4 of this application is the semiconductor raw material ingot support jig described in Claim 2 or 3, which is characterized by the aforementioned support bodies each being comprised with a pawl disposed at one end, and a weight mounted at the other end, of a support member, and with said support member mounted at its middle on a shaft disposed on the mounting member so that it can rotate freely.

[0023] The gist of the invention of Claim 5 of this application is the semiconductor raw material ingot support jig described in any of Claims 1 through 4, which is characterized by the aforementioned support bodies being mounted on said shafts at an eccentric midpoint so that activated weights of the support members are stationary at a position above the seed crystal.

[0024] The gist of the invention of Claim 6 of this application is the semiconductor raw material ingot support jig described in any of Claims 1 through 5, which is characterized by the aforementioned pawls engaging into a support groove disposed on the side surface of the semiconductor raw material ingot.

[0025] The gist of the invention of Claim 7 of this application is the semiconductor raw material ingot support jig described in any of Claims 1 through 6, which is characterized by the aforementioned operation control means being formed of a drop notch that is cut into the top of the semiconductor raw material ingot, cutting across its cross section, to a depth that is deeper than the position of the support groove.

[0026] The gist of the invention of Claim 8 of this application is the semiconductor raw material ingot support jig described in Claim 7, which is characterized by the aforementioned drop notch having a V-shaped or square sectional profile.

[0027] The gist of the invention of Claim 9 of this application is the semiconductor raw material ingot support jig described in any of Claims 2 through 8, which is characterized by the aforementioned operation control means being a solid semiconductor polycrystal or single crystal that is

disposed extending between connectors that are disposed on the support members, and by being contained inside a notch that is cut across the cross section and to a depth that is deeper than the position of the support groove.

[0028] The gist of the invention of Claim 10 of this application is the semiconductor raw material ingot support jig described in Claim 1, which is characterized by the aforementioned support means being formed on the mounting member, being formed of support parts that link with connectors that are disposed in the semiconductor raw material ingot, which support parts are each formed in a fan-shape, with a gradually increasing sectional surface area, by the aforementioned operation control means being formed of a notch that is disposed cutting across the sectional surface at the top of the semiconductor raw material ingot, with the aforementioned seed crystal enclosed within the operation control means, wherein, as the semiconductor raw material ingot is melted, the semiconductor raw material ingot is split by the semiconductor raw material ingot melting, and the semiconductor raw material ingot drops into the vessel and melts.

[0029] The gist of the invention of Claim 11 of this application is the semiconductor raw material ingot support jig described in Claim 10, which is characterized by the aforementioned support part possessing a spherical part.

[0030] The gist of the invention of Claim 12 of this application is the semiconductor raw material ingot support jig described in Claim 11, which is characterized by the aforementioned support part comprising a conical part.

[0031] The gist of the invention of Claim 13 of this application is the semiconductor raw material ingot support jig described in Claim 11, which is characterized by the spherical part of the aforementioned support part splitting away from the mounting member.

[0032] The gist of the invention of Claim 14 of this application is the semiconductor raw material ingot support jig described in Claim 11, which is characterized by the conical part of the aforementioned support part splitting away from the mounting member.

[0033] The gist of the invention of Claim 15 of this application is a seed crystal that is characterized by being enclosed inside an enclosure

disposed in the semiconductor raw material ingot, by being equipped with a single crystal growth part that grows a single crystal when placed in contact with the semiconductor raw material melt and a fan-shaped support part with a gradually increasing sectional surface area that is disposed above said single crystal growth part, by said support part being fitted into the operation control means, which is disposed in the semiconductor raw material ingot and splits due to the semiconductor raw material ingot melting, so that, as the semiconductor raw material ingot is being melted, the semiconductor raw material ingot splits due to the semiconductor raw material ingot being melted, and the semiconductor raw material ingot drops into the vessel and melts, and also exposing the seed crystal growth part.

[0034] The gist of the invention of Claim 16 of this application is the seed crystal described in Claim 15, which is characterized by the aforementioned support part possessing a spherical part.

[0035] The gist of the invention of Claim 17 of this application is the seed crystal described in Claim 15, which is characterized by the aforementioned support part possessing a conical part.

[0036] The gist of the invention of Claim 18 of this application is the seed crystal described in any of claims 15 through 17, which is characterized by the aforementioned support part being separated into multiple parts.

[0037] The gist of the invention of Claim 19 of this application is a semiconductor single crystal production method in which a seed crystal that is mounted on a pulling wire is brought into contact with a semiconductor raw material melt contained in a vessel, and a semiconductor single crystal is grown from the seed crystal, wherein which semiconductor single crystal production method is characterized by possessing a process in which a semiconductor raw material ingot is supported by a semiconductor raw material ingot support jig that possesses a mounting member, in which a pulling wire is mounted to its upper end and a seed crystal is mounted to its lower end, a support means, which is disposed on said mounting member and supports a semiconductor raw material ingot, and an operation control means that is made from a semiconductor, and which releases the support state between the support

means and the semiconductor raw material ingot, a process in which, as said semiconductor raw material ingot is being melted, its linked state with the support means is released by the melting of the operation control means, and it drops and is melted, and a process in which the aforementioned seed crystal is brought into contact with semiconductor raw material melt inside the aforementioned vessel and a single crystal is grown.

[0038] The gist of the invention of Claim 20 of this application is the semiconductor single crystal production method described in Claim 19, which is characterized by possessing a process in which a semiconductor melt is placed in advance inside the vessel as a pre-process preceding the process in which the semiconductor raw material ingot, supported by the aforementioned semiconductor raw material ingot support jig, is melted.

[0039] The gist of the invention of Claim 21 of this application is the semiconductor single crystal production method described in Claim 20, which is characterized by the aforementioned process in which a semiconductor melt is placed in advance inside the vessel is a process in which semiconductor raw material is melted inside the vessel the in initial stage of semiconductor single crystal production.

[0040] The gist of the invention of Claim 22 of this application is the semiconductor single crystal production method described in Claim 19, which is characterized by the aforementioned process in which a semiconductor melt is placed inside the vessel in advance is a process in which the semiconductor raw material melt from the previous performed semiconductor single crystal production is left in the vessel.

[0041]

[Condition of Embodiment of the Invention] The polycrystal raw material support jig and seed crystal, and the single crystal production method using them, of this invention will be explained below, referring to the attached drawings.

[0042] As shown in Figure 1, a single crystal production apparatus that uses the semiconductor single crystal production method of this invention, e.g., a CZ method single crystal pulling apparatus 1, comprises an oven

component chamber 2 and a single crystal chamber 3, which is situated above and linked to said oven component chamber 2. A vessel, e.g., a quartz crucible 6, which is built into a graphite crucible 5 and heated by a heater 4, is disposed inside the oven component chamber 2, and raw polycrystal is heated and melted inside this quartz crucible 6. The graphite crucible 5 is mounted on a crucible rotation shaft 8, which passes through the oven body 7 and is linked to and driven by a motor (not shown).

[0043] In addition, the semiconductor raw material ingot support jig 10 of this invention is disposed at the bottom end of a wire 9, which is disposed in the single crystal chamber 3 so that it can be freely raised and lowered.

[0044] As shown in Figures 2 through 4, the semiconductor raw material ingot support jig 10 possesses a mounting member 11, in which the pulling wire 9 is mounted to its upper end 11a and the seed crystal S is mounted to its other end 11b, a pair, for example, of support bodies 12, 12, which comprise the support means that is disposed on said mounting member 11 and supports the semiconductor raw material ingot M, and an operation control means 13 that, e.g., extends between the support bodies 12, 12 and releases the supported condition between said support bodies 12, 12 and the semiconductor raw material ingot M.

[0045] The support bodies 12, 12 possess support members 15, 15, with pawls 14, 14 disposed at one end, weights 17, 17, which are disposed at the other ends of said support members 15, 15 at a position bent approximately 30° inward from the rotational shafts 16, 16 of the support members 15, 15, and additional support members 19, 19 that extend parallel with support members 15, 15, and on which are disposed pawls 18, 18.

[0046] The support members 15, 15, 19, 19 are mounted so that they can rotate freely by means of the rotational shafts 16, 16 to a bearing member 20, which is assembled in rectangular shape and is disposed on the mounting member 11, while weights 17, 17 on the support members 15, 15 are mounted, as shown in Figures 5 and 6, at an eccentric midpoint so that they are stationary in a position above the seed crystal S when the operation control means 13 has melted and the support bodies 12 have operated [*sic.*]. The lengths of the

support members 15, 15, 19, 19 are determined taking into consideration the inside diameter of the single crystal chamber 3 so that the pawls 14, 14, 18, 18 do not strike the walls of the single crystal chamber 3 when the single crystal is being pulled. . In addition, the weights 17, 17 that are disposed on the respective support members 15, 15 are situated diagonally on the bearing member 20 so that the rotation of the respective weights do not interfere with one another.

[0047] The pawls 14, 14, 18, 18 are formed by making a 90° bend from the support members 15, 15, 19, 19, and as shown in Figure 2, and support of the semiconductor raw material ingot M by the support bodies 12, 12 is accomplished by engaging the four pawls 14, 14, 18, 18 disposed on the support members 15, 15, 19, 19 with the support groove 21 that is disposed in the side surface of the semiconductor raw material ingot M.

[0048] The operation control member 13 is an, e.g., U-shaped, solid semiconductor polycrystal that is provided with mounting holes (not shown) into which are inserted a pair of connectors 22, 22, which are disposed, hanging parallel with each other, on the support bodies 12, 12. The operation control member 13 extends between the pair of connectors, as described above, and is enclosed inside a rectangular notch 23 that is disposed in the top of the semiconductor raw material ingot M, cutting across its cross section, at a depth that is deeper than the position of the support groove 21.

[0049] Now, the seed crystal S is mounted on the mounting body 11 by inserting a link pin (not shown) into mounting holes (not shown), which are disposed in both the mounting member 11 and the seed crystal S.

[0050] Next, a so-called raw material replenishment system that uses the semiconductor raw material ingot support jig and semiconductor single crystal production method of this invention will be explained.

[0051] Figure 7 is a process drawing of a replenishment-type semiconductor single crystal production method, wherein the quartz crucible 6, which is situated inside the oven component chamber 2 of the single crystal pulling apparatus 1, is filled with chunks of raw silicon polycrystal m and a seed crystal S is mounted on the mounting member of the semiconductor raw

material ingot support jig 10, which is attached to the end of the wire 9 in the single crystal chamber 3. Then, as shown in Figures 2 through 4, the seed crystal is enclosed between the pair of support bodies 12, 12, the support members 15, 15, 19, 19, are hung straight down and parallel so that the pair of connectors 22, 22 are accommodated in the notch 23, and the pawls 14, 14, 18, 18 are linked into the support groove 21, thereby supporting the semiconductor raw material ingot M with the pair of support bodies 12, 12, after which, the pair of connectors 22, 22 are inserted into the operation control means 13 inside the notch 23, restricting the opening operation of the support members 15, 15, 19, 19 and supporting the semiconductor raw material ingot M by means of the semiconductor raw material ingot support jig 10 (Figure 7(a)).

[0052] Next, the heater 4, which is disposed around the outside of the quartz crucible 6, is turned on to heat and completely melt the chunks of silicon polycrystal m, filling the quartz crucible 6 approximately 80% with the silicon melt L prior to melting the silicon polycrystal ingot M (Figure 7(b)). Furthermore, the silicon polycrystal ingot M, which was prepared separately from the chunks of silicon polycrystal m and is supported by the semiconductor raw material ingot support jig 10 that was already placed inside the single crystal chamber 3, is lowered and brought into contact with the silicon melt L, melting into and supplementing it. In the process of melting this semiconductor raw material ingot M, the melting reaches the notch 23, as shown in Figures 3 and 4, and then the U-shaped polycrystal semiconductor operation control means 13 is melted, as shown in Figure 5, whereupon, the support bodies 12, 12 are opened by the force generated by the weights 17, 17, releasing the linked condition between the semiconductor raw material ingot support jig 10 and the semiconductor raw material ingot M (the remainder thereof) and dropping the semiconductor raw material ingot M into the quartz glass crucible 6, where it is melted.

[0053] When melting of the semiconductor raw material ingot M is completed, the silicon melt L nearly completely fills the quartz crucible 6. Meanwhile, when the support bodies 12, 12 open, the pawls 14, 14, 18, 18 swing

upward and the weights 17, 17 swing downward. However, since the support members 15, 15 are mounted on the mounting member 11 at an eccentric position so that they can rotate freely, the seed crystal S is exposed at the lowest position in a state where it can fulfill its function as a seed crystal during pulling (Figure 7(d)).

[0054] The interior of the single crystal pulling apparatus 1 is then brought to single crystal pulling conditions, the seed crystal S is brought into contact with the molten silicon melt L in the quartz crucible 6, and a single crystal Ig is grown on the seed crystal S (Figure 7(e)).

[0055] Furthermore, when growing and pulling of the single crystal ingot Ig is completed, there will be no re-useable molten silicon L remaining in the quartz crucible 6 (Figure 7(e)).

[0056] By using a semiconductor raw material ingot support jig 10 on which a seed crystal S is mounted to support the semiconductor raw material ingot M, according to the semiconductor single crystal production method of this invention described above, the silicon polycrystal ingot M can be melted as replenishment raw material without needing to open the oven 8 or the single crystal chamber 3 to replace the seed crystal support means with a semiconductor raw material ingot support jig. Consequently, it becomes possible to supply enough silicon melt L without contaminating the quartz crucible 6, whereby a large-volume silicon single crystal Ig can be pulled at one time with high single crystallization yield.

[0057] A gate valve for selectively separating the single crystal pulling apparatus 1 into an oven component chamber 2 and a single crystal chamber 3 also becomes unnecessary, so that the molten silicon melt L is not contaminated by dust, etc. dropping from the single crystal chamber 3 as the gate valve is opened and closed, which in turn allows the single crystallization yield to be increased since there is no hindrance to the growth of the single crystal Ig.

[0058] Furthermore, since there is no need to open the oven 7 or the single crystal chamber 3 during the series of processes, except when simultaneously charging the chunks of silicon polycrystal m and installing the

silicon polycrystal ingot M at the beginning of the pulling process, and when removing the single crystal ingot Ig that has been pulled, gas replacement also becomes unnecessary, so that the cycle time required for a single pulling operation becomes no longer than with the normal CZ method.

[0059] It is also economical since the semiconductor raw material ingot M is completely melted, without leaving any unmelted remnant on the semiconductor raw material ingot support jig.

[0060] Next, the so-called raw material recharging system, which is another condition of embodiment of the semiconductor raw material ingot support jig and semiconductor single crystal production method of this invention, will be described. The same callout numbers will be used for the same components in this description as were used in the preceding condition of embodiment.

[0061] Figure 8 is a process drawing of a recharging-type semiconductor single crystal production method, wherein a grown single crystal Ig has been pulled and there is molten silicon L remaining in the quartz crucible 6, and meanwhile, the heater is continuously operated to keep the molten silicon L in its molten state (Figure 8(a)).

[0062] Next, the gate valve 31 disposed in the single crystal chamber 3 is closed and the single crystal Ig is removed, while a seed crystal S is mounted on the mounting member 11 of a semiconductor raw material ingot support jig 10 of this invention, which is mounted on a wire 9, with the same structure as that shown in Figure 7 and used in the condition of embodiment described above. As shown in Figures 2 through 4, the semiconductor raw material ingot M is held hanging vertically while the support members 15, 15, 19, 19, are hung straight down and parallel so that the pair of connectors 22, 22 are accommodated in the notch 23, and the pawls 14, 14, 18, 18 are linked into the support groove 21, thereby supporting the semiconductor raw material ingot M with the pair of support bodies 12, 12, after which, the pair of connectors 22, 22 are inserted into the operation control means 13 inside the notch 23, restricting the opening operation of the support members 15, 15, 19,

19 and supporting the semiconductor raw material ingot M by means of the semiconductor raw material ingot support jig 10 (Figure 8(b)).

[0063] Next, the gate valve is opened and the semiconductor raw material ingot M is immersed into the silicon melt m and melted (Figure 8(c)). In the process of melting this semiconductor raw material ingot M, the melting reaches the notch 23, as shown in Figures 3 and 4, and then the U-shaped polycrystal semiconductor operation control means 13 is melted, as shown in Figure 5, whereupon, the support bodies 12, 12 are opened by the force generated by the weights 17, 17, releasing the linked condition between the semiconductor raw material ingot support jig 10 and the semiconductor raw material ingot M (the remainder thereof) and dropping the semiconductor raw material ingot M into the vessel, where it is melted. Consequently, all of the semiconductor raw material ingot M is dropped into the melt L and melted.

[0064] When melting of the semiconductor raw material ingot M is completed, the silicon melt L nearly completely fills the quartz crucible 6. Meanwhile, when the support bodies 12, 12 open, as shown in Figure 6, the seed crystal S is exposed at the lowest position in a state where it can fulfill its function as a seed crystal during pulling (Figure 8(d)).

[0065] The interior of the single crystal pulling apparatus 1 is then brought to single crystal pulling conditions, the seed crystal S is brought into contact with the molten silicon melt L in the quartz crucible 6, and a single crystal Ig is grown on the seed crystal S (Figure 8(e)).

[0066] Furthermore, while growing and pulling of the single crystal ingot Ig is completed, the quartz crucible 6, etc. is durable and, when another new single crystal is to be pulled, reusable molten silicon L will remain (Figure 8(a)).

[0067] By using a semiconductor raw material ingot support jig 10 on which a seed crystal S is mounted to support the semiconductor raw material ingot M, according to the semiconductor single crystal production method of this condition of embodiment, the single crystal chamber 3 need only be opened once to replace the seed crystal support means with a semiconductor raw material ingot support jig. Consequently, it becomes possible to pull silicon

single crystals Ig of high single crystallization yield, and to contribute to decreased semiconductor single crystal production costs. As a result, the number of times that the gate valve is opened and closed can be reduced, where in past recharging methods it had to be opened and closed at least twice, making it possible to supply enough silicon melt while reducing the danger of contamination to the oven interior by the opening and closing of the gate valve, whereby silicon single crystals can be pulled with high single crystallization yield. It is also economical since the semiconductor raw material ingot M is completely melted, without leaving any unmelted remnant on the semiconductor raw material ingot support jig.

[0068] Next, another condition of embodiment of the semiconductor raw material ingot support jig of this invention will be described. The same callout numbers will be used for the same components in this description as were used in the preceding conditions of embodiment.

[0069] As shown in Figures 9 through 12, the semiconductor raw material ingot support jig 41 possesses a mounting member 42, with a pulling wire 9 mounted at one end 42a and a seed crystal S mounted at its other end 42b, a support means, e.g., a pair of support bodies 43, 43, that are disposed on said mounting member 42 and support the semiconductor raw material ingot M, and an operation control means 44, which is situated between said support bodies 43, 43 and is disposed in the semiconductor raw material ingot M.

[0070] Each of the support bodies 43, 43 possesses support members 47, 47, each with two pawls 45, 46 disposed at one end, and weights 49, 49, which are disposed at their other end at a position that is bent approximately 30° outward from the rotational shafts 48, 48 of each of said support members 47, 47.

[0071] The support members 47, 47 are mounted on a rectangular bearing member 50, which is disposed at the center of the mounting member 42, by means of rotational shafts 48, 48 so that they can rotate freely centered around said rotational shafts 48, 48. The support members 47, 47 are also mounted on the rotational shafts 48, 48 at an eccentric midway position so that the weights 49, 49 on the support members 47, 47 are stationary at a position

above the seed crystal when the operation control means 44 has been melted and the support bodies 43, 43 have been operated [*sic.*], as shown in Figures 11 and 12.

[0072] The weights 49, 49 act to close the pawls 45, 45, 46, 46 on the support members 47, 47, which are situated diagonally from each other on the rectangular mounting member 42 so that the weights 49, 49 do not interfere with one another when they are operated.

[0073] The pawls 45, 45, 46, 46 are formed by bending the support members 47, 47 by 90°, and support of the semiconductor raw material ingot M is accomplished by the four pawls 45, 45, 46, 46 being fitted into the support groove 51.

[0074] The operation control means 44 is disposed in the top of the semiconductor raw material ingot M, and is formed by a V-shaped notch 52 that is cut across the cross section along center line c to a depth that is deeper than the position of the support groove 51. Consequently, as melting of the semiconductor raw material ingot M proceeds and the molten surface reaches the lower tip of the operation control means 44, as shown in Figures 13 and 14, the semiconductor raw material ingot M is pressed in the direction of contracting the notch 52 by the force in the closing direction exerted by the pawls 45, 45, 46, 46 of the support members 47, 47, releasing the linkage between the support groove 51 and the pawls 45, 45, 46, 46 and releasing the semiconductor raw material ingot M from the support of the support members 47, 47, so that the semiconductor raw material ingot M (the remainder thereof) entirely drops.

[0075] At this time, since the pawls 45, 45, 46, 46 are linked into the support groove 51 at positions that are off the center axis line c, or the line perpendicular to said center axis line d [*sic.*], of the notch 52 that comprises the operation control means 44, it is easier for the linkage between the support groove 51 and the pawls 45, 45, 46, 46 to be reliably released.

[0076] Now, the notch 52 that comprises the operation control means 44 is not limited to having a V-shaped cross section, and could as well have a square cross section.

[0077] If the semiconductor raw material ingot support jig 41 of this condition of embodiment is used in a raw material replenishing-type single crystal production method, the silicon polycrystal ingot M can be melted as replenishment raw material without needing to open the oven 8 or the single crystal chamber 3 to replace the seed crystal support means with a semiconductor raw material ingot support jig. Consequently, it becomes possible to supply enough silicon melt L without contaminating the quartz crucible 6, whereby a large-volume silicon single crystal Ig can be pulled at one time with high single crystallization yield.

[0078] It also becomes unnecessary to selectively separate the single crystal pulling apparatus 1 into an oven component chamber 2 and a single crystal chamber 3 by means of a gate valve, so that the molten silicon melt L is not contaminated by dust, etc. dropping from the single crystal chamber 3 as the gate valve is opened and closed, which in turn allows the single crystallization yield to be increased since there is no hindrance to the growth of the single crystal Ig.

[0079] Furthermore, since there is no need to open the oven 7 or the single crystal chamber 3 during the series of processes, except when simultaneously charging the chunks of silicon polycrystal m and installing the silicon polycrystal ingot M at the beginning of the pulling process, and when removing the single crystal ingot Ig that has been pulled, gas replacement also becomes unnecessary, so that the cycle time required for a single pulling operation becomes no longer than with the normal CZ method.

[0080] It is also economical since the semiconductor raw material ingot M is completely melted, without leaving any on the semiconductor raw material ingot support jig.

[0081] In addition, if a semiconductor raw material ingot support jig 41, on which a seed crystal S is mounted, is used to support the semiconductor raw material ingot M in a recharging system, the single crystal chamber 3 need only be opened once to replace the seed crystal support means with a semiconductor raw material ingot support jig. Consequently, it becomes possible to pull silicon single crystals Ig of high single crystallization

yield, and to contribute to decreased semiconductor single crystal production costs. As a result, the number of times that the gate valve is opened and closed can be reduced, where in past recharging methods it had to be opened and closed at least twice, making it possible to supply enough silicon melt while reducing the danger of contamination to the oven interior by the opening and closing of the gate valve, whereby silicon single crystals can be pulled with high single crystallization yield.

[0082] Furthermore, another condition of embodiment of the semiconductor raw material ingot support jig of this invention will be described. The same callout numbers will be used for the same components in this description as were used in the preceding conditions of embodiment.

[0083] As shown in Figures 15 and 16, the semiconductor raw material ingot support jig 61 possesses a mounting member 62, which is made from a metal, such as tungsten or molybdenum, etc., or a metallic compound or carbon or a carbon compound, with a pulling wire 9 mounted at one end 62a and a seed crystal S mounted at its other end 62b, a support means, e.g., a support part 64, which is disposed on said mounting member 62 and links into a catch 63 disposed in the semiconductor raw material ingot M, and which supports the semiconductor raw material ingot M, and an operation control means 64, which is disposed in the semiconductor raw material ingot M.

[0084] Part of the support part 64 is formed into a fan shape with a gradually increasing sectional surface area, which expands from the mounting member 62, e.g., a cone.

[0085] The operation control means 65 possesses a long, narrow, U-shaped notch 66, which is disposed in the top of the semiconductor raw material ingot M and is cut along the center line c, and a catch part 63, which is disposed at the top of said notch 66 and whose sectional profile has a fan-shape that matches the shape of the conical part of the mounting member 62. The U-shaped notch has a depth that is sufficient to accommodate the seed crystal S mounted on the mounting means 62.

[0086] Consequently, as show in Figures 17 and 18, as melting of the semiconductor raw material ingot M progresses and the melt surface reaches the

bottom end 65d of the operation control means 65, force is exerted on the semiconductor raw material ingot M (the remainder thereof) by its own weight in the direction spreading the catch hole 83, releasing the linkage between the catch part hole 83 and the support part 82 and releasing the semiconductor raw material ingot M from the state of being supported by the seed crystal S1, so that the semiconductor raw material ingot M (the remainder thereof) completely drops. The seed crystal S1 (single crystal growth part S1a) is then exposed by the semiconductor raw material ingot M dropping.

[0087] Now, the support part 71 is not limited to employing a partial conical shape, but may also have a spherical part, as shown in Figure 20, or, as shown in Figures 21(a) through (c), may also be formed so that the support part can be separated from the mounting member 73. If the support part 71 is formed with a spherical part, the linkage between the catch part 63 and the support part 71 can be easily released regardless of the sectional profile of the catch part 63. In addition, if the support part 72 is separable, if the support part becomes deteriorated, the unit can be reused by replacing only said support part 72.

[0088] Furthermore, it is preferable for the support parts 71, 72 to be made of the same substance as the semiconductor raw material as this makes it possible to avoid contamination by contact between the raw ingot M and the support parts 71, 72.

[0089] If the semiconductor raw material ingot support jig 61 of this condition of embodiment is used in a raw material replenishment-type single crystal production method, it becomes possible to supply enough silicon melt L without contaminating the quartz crucible 6, whereby a large-volume silicon single crystal Ig can be pulled at one time with high single crystallization yield. In addition, the molten silicon melt L is not contaminated by dust, etc. dropping from the single crystal chamber 3 as the gate valve is opened and closed, which in turn allows the single crystallization yield to be increased since there is no hindrance to the growth of the single crystal Ig.

[0090] Furthermore,

[0058] Furthermore, gas replacement also becomes unnecessary, so that the cycle time required for a single pulling operation becomes no longer than with the normal CZ method, and production becomes economical since the semiconductor raw material ingot M is completely melted, without leaving any unmelted remnant on the semiconductor raw material ingot support jig. Since the support part 64 is formed by expanding the mounting member 62, an economical semiconductor raw material ingot support jig with a simple structure and no moving parts can be provided. In addition, using a separable support part 72 is economical since only said support part 72 is replaced when the support part 72 deteriorates, allowing the semiconductor raw material ingot support jig 61 to be restored to its original condition without needing to be completely replaced. Furthermore, when it is necessary to perform chemical etching to remove the contaminants at the completion of each pulling, only the seed crystal S needs to be chemically etched, and not the entire semiconductor raw material ingot support jig 61, facilitating greater longevity.

[0091] In addition, when used in a recharging system, as with the semiconductor raw material ingot support jigs in the conditions of embodiment described above, it becomes possible to pull silicon single crystals Ig of high single crystallization yield, and to contribute to decreased semiconductor single crystal production costs. Furthermore, it becomes possible to supply enough silicon melt while reducing the danger of contamination to the oven interior by the opening and closing of the gate valve, whereby silicon single crystals can be pulled with high single crystallization yield.

[0092] Furthermore, the seed crystal of this invention will be described.

[0093] As shown in Figures 22 and 23, the seed crystal S1 of this invention possesses a single crystal growth part S1 at its lower end and a support part 82, which is situated above said seed crystal growth part S1, links with the operation control means 81 disposed in the semiconductor raw material ingot M, and is formed with a fan shape with a gradually increasing sectional surface area, e.g., with a spherical part, and possesses two

functions of growing a single crystal and of supporting the semiconductor raw material ingot M.

[0094] The operation control means 81 possesses a catch hole 83 that is disposed on the top of the semiconductor raw material ingot M, a penetrating hole 84, which is contiguous with said catch hole 83, has a diameter that is greater than the diameter of said catch hole 83, and penetrates the semiconductor raw material ingot M along its length, and a splitting groove 85 that reaches downward past the position reached by the single crystal growth part S1a when the support part 82 is engaged with the catch hole 83. This splitting groove 85 is formed across the cross section of the semiconductor raw material ingot M, so that the semiconductor raw material ingot M (the remainder thereof) splits when the semiconductor raw material ingot M is melted up to said splitting groove 85.

[0095] The semiconductor raw material ingot M is mounted on the seed crystal S1 by passing the seed crystal S1 through the penetrating hole 84 with the single crystal growth part S1 pointing downward and catching the support part 82 on the catch hole 83, and then attaching the seed crystal S1 to the mounting member (not shown).

[0096] Consequently, when the semiconductor raw material ingot M is being melted, as melting of the semiconductor raw material ingot M progresses and the melt surface l reaches the bottom end of the splitting groove 85 in the semiconductor raw material ingot M (the remainder thereof), force is exerted on the semiconductor raw material ingot M (the remainder thereof) by its own weight in the direction spreading the notch 66, releasing the linkage between the catch part 63 and the support part 64 and releasing the semiconductor raw material ingot M from the state of being supported by the semiconductor raw material ingot support jig 61, so that the semiconductor raw material ingot M (the remainder thereof) completely drops. The exposed seed crystal S is then brought into contact with the melt and a single crystal Ig is grown, as shown in Figure 19.

[0097] If the seed crystal S1 of this condition of embodiment is used in a raw material replenishing-type single crystal production method, as with the

semiconductor raw material ingot support jig of the first condition of embodiment described above, it becomes possible to supply enough silicon melt L without contaminating the quartz crucible 6, whereby a large-volume silicon single crystal Ig can be pulled at one time with high single crystallization yield. In addition, the molten silicon melt L is not contaminated by dust, etc. dropping from the single crystal chamber 3 as the gate valve is opened and closed, which in turn allows the single crystallization yield to be increased since there is no hindrance to the growth of the single crystal Ig. Furthermore, gas replacement also becomes unnecessary, so that the cycle time required for a single pulling operation becomes no longer than with the normal CZ method, and production is economical since the semiconductor raw material ingot M is completely melted, without leaving any on the semiconductor raw material ingot support jig. Furthermore, since the support part 82 is formed expanding as a single unit from the seed crystal S1, an economical semiconductor raw material ingot support jig with a simple structure and no moving parts can be provided.

[0098] In addition, when used in a recharging system, as with the semiconductor raw material ingot support jigs in the conditions of embodiment described above, it becomes possible to pull silicon single crystals Ig of high single crystallization yield, and to contribute to decreased semiconductor single crystal production costs. Furthermore, it becomes possible to supply enough silicon melt while reducing the danger of contamination to the oven interior by the opening and closing of the gate valve, whereby silicon single crystals can be pulled with high single crystallization yield.

[0099] Now, the support part 82 is not limited to employing a partially conical shape, and may as well have a spherical part.

[0100] It may also be provided with multiple, separate support parts 86, that are formed with gradually expanding sectional areas, e.g., spherical parts, as shown in Figure 25 [*sic.*], a square notch 87 may be disposed cutting across the cross section at the top of the semiconductor raw material ingot M, linkage grooves 88 may be disposed parallel with the top of said notch 87, and

a catch hole 89 may be disposed contiguous with these linkage grooves 88, so that the support part 86 engages with this catch hole 89.

[0101] If the support part 86 is formed into a sphere, the linkage between the catch hole 89 and the support part 86 can be easily released, regardless of the shape of the sectional profile of the catch hole 89. In addition, if multiple, separate support marts 86 are provided, it can easily be utilized for multiple replenishment melt operations.

[0102]

[Example Embodiments] Test 1: A 15kg, 127mm-diameter, 600mm-long silicon polycrystal rod was melted using a semiconductor raw material ingot support jig like that shown in Figure 3 and compared with a comparison example.

[0103] Result: The entire 15kg of the polycrystal raw material rod were able to be melted in this example embodiment. In addition, since the support body rose to above the seed crystal after melting of the polycrystal raw material rod was completed, the operation was able to shift immediately to growth of the single crystal, without an operation to replace the polycrystal raw material rod support jig with a seed crystal.

[0104] In contrast, while up to approximately 12kg of a polycrystal raw material rod was able to be melted in a comparison example using a wire-wrap support method, the remaining almost 3kg could not be melted. In addition, the operation to mount a seed crystal after the polycrystal raw material rod had been melted required approximately 1.5 hours.

Test 2: A 15kg, 127mm-diameter, approximately 600mm-long silicon polycrystal rod was melted using a semiconductor raw material ingot support jig like that shown in Figure 11 and compared with a comparison example.

[0105] Result: Similar results to those in Test 1, above, were obtained.

[0106] Test 3: A 27kg, 140mm-diameter, approximately 860mm-long silicon polycrystal rod was melted using a semiconductor raw material ingot support jig like that shown in Figure 16 and compared with a comparison example.

[0107] Result: The entire 27kg of the polycrystal raw material rod were able to be melted in this example embodiment. In addition, since the support body rose to above the seed crystal after melting of the polycrystal raw

material rod was completed, the operation was able to shift immediately to growth of the single crystal, without an operation to replace the polycrystal raw material rod support jig with a seed crystal.

[0108] In contrast, while up to approximately 25kg of a polycrystal raw material rod was able to be melted in a comparison example using a wire-wrap support method, the remaining almost 2kg could not be melted. In addition, the operation to mount a seed crystal after the polycrystal raw material rod had been melted required approximately 1.5 hours.

Test 4: A silicon polycrystal rod was melted in a raw material replenishment system, using a seed crystal like that shown in Figure 23, and compared with a comparison example.

[0109] Result: Since an operation to replace the polycrystal raw material rod support jig with a seed crystal was not required, the single crystal pulling time was able to me shortened by approximately 60 minutes over with comparison example.

[0110]

[Effect] With the semiconductor raw material ingot support jig and seed crystal, and single crystal production method using them, of this invention, a semiconductor raw material ingot support jig and seed crystal, and single crystal production method using them, can be provided that do not contaminate the interior of the semiconductor single crystal production apparatus when supplying the semiconductor raw material ingot, that provide for improved single crystallization yield, and that do not lengthen the cycle time required for a single pulling, and furthermore that make it possible to melt the entire semiconductor raw material ingot.

[0111] In other words, since the semiconductor raw material ingot is supported by a support means on which a seed crystal is mounted, and since the support of the semiconductor raw material ingot is released by means of a semiconductor production operation control means that releases the support state while the semiconductor raw material ingot is being melted, allowing the semiconductor raw material ingot to drop into the vessel and be melted, if the semiconductor raw material ingot support jig of this invention is used in a

raw material replenishing single crystal production method, the silicon polycrystal ingot M can be melted as replenishment raw material without needing to open the oven or the single crystal chamber to replace the seed crystal support means with a semiconductor raw material ingot support jig. Consequently, it becomes possible to supply enough silicon melt without contaminating the quartz crucible, whereby a large-volume silicon single crystal can be pulled at one time with high single crystallization yield. In addition, a gate valve for selectively separating the single crystal pulling apparatus into an oven component chamber and a single crystal chamber becomes unnecessary, so that the molten silicon melt is not contaminated by dust, etc. dropping from the single crystal chamber as the gate valve is opened and closed, which in turn allows the single crystallization yield to be increased since there is no hindrance to the growth of the single crystal.

[0112] Furthermore, since there is no need to open the oven or the single crystal chamber during the series of processes, except when simultaneously charging the chunks of silicon polycrystal and installing the silicon polycrystal ingot at the beginning of the pulling process, and when removing the single crystal ingot that has been pulled, gas replacement also becomes unnecessary, so that the cycle time required for a single pulling operation becomes no longer than with the normal CZ method. It is also economical since the semiconductor raw material ingot is completely melted, without leaving any unmelted remnant on the semiconductor raw material ingot support jig.

[0113] In addition, if a semiconductor raw material ingot support jig, on which a seed crystal is mounted, is used to support the semiconductor raw material ingot, when using a recharging system, the single crystal chamber need only be opened once to replace the seed crystal support means with a semiconductor raw material ingot support jig. Consequently, it becomes possible to pull silicon single crystals of high single crystallization yield, and to contribute to decreased semiconductor single crystal production costs. As a result, the number of times that the gate valve is opened and closed can be reduced, where in past recharging methods it had to be opened and closed at least twice, making it possible to supply enough silicon melt while reducing

the danger of contamination to the oven interior by the opening and closing of the gate valve, whereby silicon single crystals can be pulled with high single crystallization yield.

[0114] Additionally, since the support means is disposed on the mounting member so that it can be opened or closed, and is formed of multiple support bodies that support the semiconductor raw material ingot by pinching it with said opening operation or closing operation, the semiconductor raw material ingot can be securely supported and the seed crystal can be enclosed within the support body, providing for conservation of space.

[0115] In addition, since the support body comprises support members with pawls disposed at one end and weights mounted at their other end, which are mounted so that they can rotate freely around rotational shafts that are disposed midway on the mounting member, the semiconductor raw material ingot can be securely supported, and support of the semiconductor raw material ingot can be automatically released by the support body by the action of the weights.

[0116] In addition, since support bodies are mounted on the rotational shafts at eccentric midpoints so that the weights of the operating support bodies are stationary at a position above the seed crystal, the seed crystal can be reliably positioned at the lowest point.

[0117] Additionally, by engaging the pawls in a support groove that is disposed on the side surface of the semiconductor raw material ingot, the semiconductor raw material ingot can be easily and securely supported and released with a simple structure.

[0118] Furthermore, since the operation control means is formed in a drop notch that is cut in the top of the semiconductor raw material ingot M across its cross section, to a depth that is deeper than the position of the support groove, the semiconductor raw material ingot can be reliably dropped and melted during the process of melting the semiconductor raw material ingot.

[0119] In addition, since the sectional profile of the drop notch is V-shaped or square, the semiconductor raw material ingot can be reliably dropped and melted regardless of this simple structure.

[0120] Additionally, since the operation control means is a solid semiconductor polycrystal or single crystal that extends between connectors disposed on the support members, and since it is enclosed within a notch that is cut to a depth that is deeper than the position of the support groove, the semiconductor raw material ingot can be reliably dropped and melted during the process of melting the semiconductor raw material ingot, and since it is made of a semiconductor, purity is not compromised and the single crystallization yield is not decreased.

[0121] Furthermore, since the support part that comprises the support means is formed in a fan shape with a gradually increasing sectional area, the operation control means is formed as a notch disposed in the top of the semiconductor raw material ingot and cutting across its cross section, and the seed crystal is enclosed within the operation control means, an economical semiconductor raw material ingot support jig with a simple structure and no moving parts can be provided. Furthermore, when it is necessary to perform chemical etching to remove the contaminants at the completion of each pulling, only the seed crystal needs to be chemically etched, and not the entire semiconductor raw material ingot support jig, facilitating greater longevity.

[0122] In addition, since the support part possesses a spherical part, the linkage between the catch part and the support part can be easily released regardless of the sectional profile of the catch part.

[0123] Additionally, since the support part is formed with a conical part, the linkage between the catch part and the support part can be easily released, and the semiconductor raw material ingot can be reliably dropped.

[0124] Furthermore, since the spherical part can be separated from the mounting member, if the support part becomes deteriorated, the unit can be reused by replacing only said support part, without replacing the entire semiconductor raw material ingot support jig, economically restoring the unit to its original condition.

[0125] In addition, since the conical part can be separated from the mounting member, if the support part becomes deteriorated, the unit can be reused by replacing only said support part, without replacing the entire

semiconductor raw material ingot support jig, economically restoring the unit to its original condition.

[0126] Additionally, since the seed crystal is equipped with a single crystal growth part that is accommodated by a void disposed in the semiconductor raw material ingot, and which causes a single crystal to grow when brought into contact with the semiconductor raw material melt, and fan-shaped support part with a gradually increasing sectional area, which is disposed above said single crystal growth part, when used in a raw material replenishing-type or recharging-type single crystal production method, it becomes possible to supply enough silicon melt without contaminating the quartz crucible, enabling a high-volume silicon single crystal to be pulled at one time with high single crystallization yield. Furthermore, gas replacement also becomes unnecessary, so that the cycle time required for a single pulling operation becomes no longer than with the normal CZ method, and the process is economical since the semiconductor raw material ingot is completely melted, without leaving any unmelted remnant on the semiconductor raw material ingot support jig. Additionally, since the support part is formed expanding as a single unit into the seed crystal, it can be used as an economical semiconductor raw material ingot support jig with a simple structure and no moving parts.

[0127] In addition, since the silicon single crystal support part possesses a spherical part, the linkage between the catch part and the support part can be easily released regardless of the sectional profile of the catch part, and the semiconductor raw material ingot can be reliably dropped.

[0128] Additionally, since the silicon single crystal support part is formed with a conical part, the linkage between the catch part and the support part can be easily released, and the semiconductor raw material ingot can be reliably dropped.

[0129] Furthermore, since there are multiple, separate support parts provided, it is convenient for easy use for multiple replenishment melting.

[0130] In addition, if a semiconductor single crystal production method, which possesses a process in which a semiconductor raw material ingot is

supported by a semiconductor raw material ingot support jig that possesses a mounting member, in which a pulling wire is mounted to its upper end and a seed crystal is mounted to its lower end, a support means, which is disposed on said mounting member and supports a semiconductor raw material ingot, and an operation control means that is made from a semiconductor, and which releases the support state between the support means and the semiconductor raw material ingot, is used in a raw material replenishing-type single crystal production method, the silicon polycrystal ingot can be melted as replenishment raw material without needing to open the oven or the single crystal chamber to replace the seed crystal support means with a semiconductor raw material ingot support jig, and it becomes possible to supply enough silicon melt without contaminating the quartz crucible, whereby a large-volume silicon single crystal can be pulled at one time with high single crystallization yield. It also becomes unnecessary to selectively separate the single crystal pulling apparatus into an oven component chamber and a single crystal chamber by means of a gate valve, so that the molten silicon melt is not contaminated by dust, etc. dropping from the single crystal chamber as the gate valve is opened and closed, which in turn allows the single crystallization yield to be increased since there is no hindrance to the growth of the single crystal.

[0131] Furthermore, since there is no need to open the oven or the single crystal chamber during the series of processes, except when simultaneously charging the chunks of silicon polycrystal and installing the silicon polycrystal ingot at the beginning of the pulling process, and when removing the single crystal ingot that has been pulled, gas replacement also becomes unnecessary, so that the cycle time required for a single pulling operation becomes no longer than with the normal CZ method. It is also economical since the semiconductor raw material ingot is completely melted, without leaving any on the semiconductor raw material ingot support jig.

[0132] Additionally, if used in a recharging system, the single crystal chamber need only be opened once to replace the seed crystal support means with a semiconductor raw material ingot support jig. Consequently, it becomes

possible to pull silicon single crystals of high single crystallization yield, and to contribute to decreased semiconductor single crystal production costs. As a result, the number of times that the gate valve is opened and closed can be reduced, where in past recharging methods it had to be opened and closed at least twice, making it possible to supply enough silicon melt while reducing the danger of contamination to the oven interior by the opening and closing of the gate valve, whereby silicon single crystals can be pulled with high single crystallization yield.

[Brief Explanation of the Figures]

[Figure 1] This is an explanatory drawing showing a condition of embodiment of the semiconductor single crystal production method of this invention.

[Figure 2] This shows the state in which a semiconductor raw material ingot is supported by a condition of embodiment of the semiconductor raw material ingot support jig of this invention, wherein (a) is a side-view drawing thereof, and (b) is the cross section drawing along c-c' in (a).

[Figure 3] This is a plan-view drawing of a condition of embodiment of the semiconductor raw material ingot support jig of this invention.

[Figure 4] This is a side-view drawing of a condition of embodiment of the semiconductor raw material ingot support jig of this invention.

[Figure 5] This is an explanatory drawing showing the operating state of a condition of embodiment of the semiconductor raw material ingot support jig of this invention.

[Figure 6] This is an explanatory drawing showing the operating state of a condition of embodiment of the semiconductor raw material ingot support jig of this invention.

[Figure 7] Figures (a) through (f) are a manufacturing process diagram of a condition of embodiment in which the various semiconductor single crystal production methods of this invention is used in a raw material replenishment-type single crystal production method.

[Figure 8] Figures (a) through (e) are a manufacturing process diagram of a condition of embodiment in which the various semiconductor single crystal

production methods of this invention is used in a recharging-type single crystal production method.

[Figure 9] This is a plan-view drawing of another condition of embodiment of the semiconductor raw material ingot support jig of this invention.

[Figure 10] This shows the state in which a semiconductor raw material ingot is supported by another condition of embodiment of the semiconductor raw material ingot support jig of this invention, wherein (a) is a plan-view drawing thereof, and (b) is a cross section drawing thereof.

[Figure 11] This is a plan-view drawing of another condition of embodiment of the semiconductor raw material ingot support jig of this invention.

[Figure 12] This is a side-view drawing of another condition of embodiment of the semiconductor raw material ingot support jig of this invention.

[Figure 13] This is an explanatory drawing of the operating state of another condition of embodiment of the semiconductor raw material ingot support jig of this invention.

[Figure 14] This is an explanatory drawing of the operating state of another condition of embodiment of the semiconductor raw material ingot support jig of this invention.

[Figure 15] This is a plan-view drawing of another condition of embodiment of the semiconductor raw material ingot support jig of this invention.

[Figure 16] This shows the state in which a semiconductor raw material ingot is supported by another condition of embodiment of the semiconductor raw material ingot support jig of this invention, wherein (a) is a plan-view drawing thereof, and (b) is a cross section drawing thereof.

[Figure 17] This is an explanatory drawing of the operating state of another condition of embodiment of the semiconductor raw material ingot support jig of this invention.

[Figure 18] This is an explanatory drawing of the operating state of another condition of embodiment of the semiconductor raw material ingot support jig of this invention.

[Figure 19] This is an explanatory drawing of the state in which a single crystal is being pulled using another condition of embodiment of the semiconductor raw material ingot support jig of this invention.

[Figure 20] This is an explanatory drawing showing an example modification of another condition of embodiment of the semiconductor raw material ingot support jig of this invention.

[Figure 21] Figures (a) through (c) are explanatory drawings showing example modifications of another condition of embodiment of the semiconductor raw material ingot support jig of this invention.

[Figure 22] This is a cross-sectional drawing showing another condition of embodiment of the semiconductor raw material ingot support jig of this invention.

[Figure 23] This is a cross-sectional drawing showing an example modification of another condition of embodiment of the semiconductor raw material ingot support jig of this invention.

[Figure 24] This is a past semiconductor single crystal production method.

[Figure 25] Figures (a) through (f) are a manufacturing process diagram of a past raw material replenishment-type single crystal production method.

[Figure 26] Figures (a) through (e) are a manufacturing process diagram of a past recharging-type single crystal production method.

[Legend]

1	single crystal production apparatus
2	oven component chamber
3	single crystal chamber
4	heater
5	graphite crucible
6	quartz crucible
7	oven
8	crucible rotation shaft
9	pulling wire
10	semiconductor raw material ingot support jig

11	mounting member
11a	one end
11b	the other end
12	support body
13	operation control means
14	pawl
15	support member
16	rotational shaft
17	weight
18	pawl
19	support member
20	bearing member
21	support groove
22	connector
23	notch
M	semiconductor raw material ingot (silicon polycrystal ingot)
S	seed crystal
41	semiconductor raw material ingot support jig
42	mounting member
42a	one end
42b	the other end
43	support member
44	operation control means
45	pawl
46	pawl
47	support member
48	rotational shaft
49	weight
50	bearing member
51	support groove
52	notch
61	semiconductor raw material ingot support jig

62 mounting member

62a one end

62b the other end

63 catch part

64 support part

65 operation control means

65d bottom end

66 notch

71 support part

72 support part

81 operation control means

82 support part

83 catch hole

84 penetrating hole

85 splitting groove

86 support part

87 notch

88 catch grooves

89 catch hole

S1 seed crystal

S1a single crystal growth part

[Fig. 9] [Fig. 17] [Fig. 18] [Fig. 29]

[FIGURES]

[Fig. 1] [Fig. 2] [Fig. 3] [Fig. 4]

[FIGURE] [FIGURES]

-Legend-
1 single crystal production apparatus
2 oven component chamber
3 single crystal chamber
4 heater
6 quartz crucible
10 seed crystal holding means
11 mounting member
13 operation control means
M semiconductor raw material ingot (silicon polycrystal ingot)
S seed crystal

[Fig. 15]

[Fig. 10] [Fig. 12]

[FIGURES]

[Fig. 5] [Fig. 6]

[Fig. 11]

[Fig. 13]

[FIGURES]

[Fig. 19]

[Fig. 7]

[Fig. 8]

[FIGURES]

[Fig. 14]

[Fig. 16]

[Fig. 21]

[FIGURES]

[Fig. 22] [Fig. 23] [Fig. 24]

[FIGURES]

[Fig. 25] [Fig. 26]

[FIGURES]

3.

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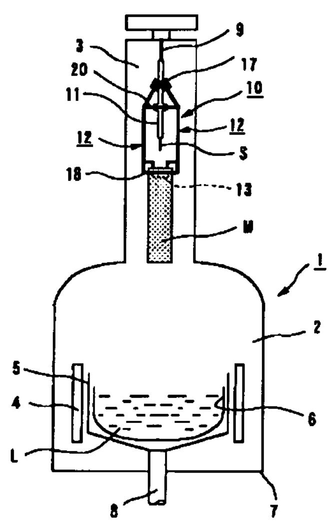
最終頁に続く

(54)【発明の名称】　半導体原料塊支持治具および種結晶ならびにこれを用いた単結晶の製造方法

(57)【要約】　　（修正有）

【課題】半導体原料塊の供給時、半導体単結晶製造装置内を汚染することがなく、単結晶化率の向上が図れ、かつ1回の引上げに要するサイクルタイムも長くならなず、さらに、半導体原料塊を未溶融部が残らず完全に溶融できる多結晶原料支持治具およびと種結晶ならびにこれを用いた単結晶の製造方法を提供する。

【解決手段】上端１１ａに引上げ用ワイヤ９が取付けられ下端１１ｂに種結晶Ｓが取付けられる取付部材１１と、この取付部材１１に設けられ半導体原料塊Ｍを支持する支持手段１２と、この支持手段１２と半導体原料塊Ｍとの支持状態を解除する半導体製の動作制御手段１３とを有し、半導体原料塊Ｍを溶融させる途中で前記動作制御手段１３の溶融に因り、支持手段１２による半導体原料塊Ｍの支持を解除して、半導体原料塊Ｍを容器６内に落下、溶融させる半導体原料塊支持治具。



1:単結晶製造装置
2:炉部材収納室
3:単結晶収納部
4:ヒータ
6:石英ルツボ
10:半導体原料塊支持治具
11:取付部材
13:動作制御手段
M:半導体原料塊(多結晶ｼﾘｺﾝ塊)
S:種結晶

【特許請求の範囲】
【請求項１】 上端に引上げ用ワイヤが取付けられ下端に種結晶が取付けられる取付部材と、この取付部材に設けられ半導体原料塊を支持する支持手段と、この支持手段と半導体原料塊との支持状態を解除する半導体製の動作制御手段とを有し、半導体原料塊を溶融させる途中で前記動作制御手段の溶融に因り、支持手段による半導体原料塊の支持を解除して、半導体原料塊を容器内に落下、溶融させることを特徴とする半導体原料塊支持治具。
【請求項２】 上記支持手段は、取付部材に開閉動作可能に設けられ開動作または閉動作により半導体原料塊を挟むように支持する複数個の支持体で形成されていることを特徴とする請求項１に記載の半導体原料塊支持治具。
【請求項３】 上記支持手段は、取付部材に開閉動作可能に設けられ、半導体原料塊を支持している状態では支持体間に種結晶を収納し、半導体原料塊の容器内への落下、溶融状態では種結晶を露出させていることを特徴とする請求項１または２に記載の半導体原料塊支持治具。
【請求項４】 上記支持体は、一端に爪部が設けられ、他端に重りが取付けられた支持部材を、その中間部で取付部材に設けられた軸に回動自在に取付けたことを特徴とする請求項２または３に記載の半導体原料塊支持治具。
【請求項５】 上記支持体は、動作した支持体の重りが種結晶の上方に位置して静止するように、偏倚した中間部で軸に取付けられていることを特徴とする請求項２ないし４のいずれか１項に記載の半導体原料塊支持治具。
【請求項６】 上記爪部は、半導体原料塊の側面部に設けられた支持溝に係合することを特徴とする請求項２ないし５のいずれか１項に記載の半導体原料塊支持治具。
【請求項７】 上記動作制御手段は、支持溝の位置よりも深く半導体原料塊の上部に断面を横断して切込まれた落下用切欠部で形成されたことを特徴とする請求項１ないし６のいずれか１項に記載の半導体原料塊支持治具。
【請求項８】 上記落下用切欠部は、断面が楔形状または矩形形状であることを特徴とする請求項７に記載の半導体原料塊支持治具。
【請求項９】 上記動作制御手段は、支持部材に設けられた連結子間に橋設される固形半導体多結晶または単結晶であり、かつ、断面を横断し支持溝の位置よりも深く切込まれた切欠部内に収容されていることを特徴とする請求項２ないし８のいずれか１項に記載の半導体原料塊支持治具。
【請求項１０】 上記支持手段は、取付部材に形成され、半導体原料塊に設けられた係合部に係合する支持部で形成され、この支持部はその断面積が順次増大するような末広形状に形成され、上記動作制御手段は半導体原料塊の上部に断面を横断して設けられた切欠部で形成され、上記種結晶は動作制御手段内に収納されており、半導体原料塊を溶融させる途中で半導体原料塊の溶融に因り半導体原料塊が分割されて支持部による半導体原料塊の支持が解除され、半導体原料塊を容器内に落下、溶融させることを特徴とする請求項１に記載の半導体原料塊支持治具。
【請求項１１】 上記支持部は、球面部を有することを特徴とする請求項１０に記載の半導体原料塊支持治具。
【請求項１２】 上記支持部は、円錐体部で形成されていることを特徴とする請求項１１に記載の半導体原料塊支持治具。
【請求項１３】 上記支持部は、球面部が取付部材から分割されることを特徴とする請求項１１に記載の半導体原料塊支持治具。
【請求項１４】 上記支持部は、円錐体部が取付部材から分割されることを特徴とする請求項１２に記載の半導体原料塊支持治具。
【請求項１５】 半導体原料塊に設けられた収納部に収納され、半導体原料融液に接触させて単結晶を成長させる単結晶成長部と、この単結晶成長部の上方に設けられ、断面積が順次増大する末広形状の支持部とを具備し、この支持部は半導体原料塊に設けられ半導体原料塊の溶融に因り分割される動作制御手段に係合し、半導体原料塊を溶融させる途中で半導体原料塊の溶融に因り半導体原料塊が分割されて支持部による半導体原料塊の支持が解除され、半導体原料塊を容器内に落下、溶融させると共に、単結晶成長部を露出させることを特徴とする種結晶。
【請求項１６】 上記支持部は、球面部を有することを特徴とする請求項１５に記載の種結晶。
【請求項１７】 上記支持部は、円錐体部で形成されていることを特徴とする請求項１５に記載の種結晶。
【請求項１８】 上記支持部は、離間して複数個設けられることを特徴とする請求項１５ないし１７のいずれか１項に記載の種結晶。
【請求項１９】 容器内に収容された半導体原料融液に、引上げ用ワイヤに取付けられた種結晶を接触させて、種結晶から半導体単結晶を成長させる半導体単結晶の製造方法において、上端に引上げ用ワイヤが取付けられ下端に種結晶が取付けられる取付部材と、この取付部材に設けられ半導体原料塊を支持する支持手段と、この支持手段と半導体原料塊との支持状態を解除する半導体製の動作制御手段とを有する半導体原料塊支持治具により半導体原料塊を支持する工程と、この半導体原料塊を溶融させる途中で動作制御手段の溶融に因り支持手段との係合状態を解除して半導体原料塊を容器内に落下させ溶融させる工程と、前記容器内の半導体原料融液に前記種結晶を接触させて単結晶を成長させる工程とを有することを特徴とする半導体単結晶の製造方法。
【請求項２０】 上記半導体原料塊支持治具に支持され

た半導体原料塊を溶融させる工程に先行する前工程として、予め容器内に半導体融液を収容させておく工程を有することを特徴とする請求項１９に記載の半導体単結晶の製造方法。

【請求項２１】　上記予め容器内に半導体融液を収容させておく工程は、半導体単結晶の製造の初期に容器内に半導体原料を溶融させる工程であることを特徴とする請求項２０に記載の半導体単結晶の製造方法。

【請求項２２】　上記予め容器内に半導体融液を収容させておく工程は、先行して行われる半導体単結晶の製造において半導体原料融液を残存させておく工程であることを特徴とする請求項１９に記載の半導体単結晶の製造方法。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は半導体原料塊支持治具および種結晶ならびにこれを用いた単結晶の製造方法に係わり、特に半導体原料の供給方法を改善し単結晶化率の向上を図った半導体原料塊支持治具および種結晶ならびにこれを用いた単結晶の製造方法に関する。

【０００２】

【従来の技術】一般に半導体ウェーハの製造方法は、多結晶半導体原料を溶融させ、この原料融液に単結晶よりなる種結晶を接触させ、種結晶から半導体単結晶を成長させる半導単結晶の製造方法が用いられている。

【０００３】例えば、チョクラルスキー法（以下、ＣＺ法という。）によるインゴット状のシリコン単結晶の製造方法は、図２４に示すように、単結晶製造装置９１の炉部材収納室９２内に設置された石英ルツボ９３に不定形な小塊形状の原料の多結晶シリコンｍ０を充填し、石英ルツボ９３の外周に設けられたヒータ９４によって多結晶シリコンｍ０を完全に加熱溶融させた後、シードチャック９５に取付けられた種結晶（シード結晶）Ｓ０をシリコン融液に浸し、種結晶Ｓ０と石英ルツボ９３を逆方向に回転させ種結晶Ｓ０を引上げてシリコン単結晶Ｉｇ０を成長させるものである。

【０００４】一般に使用される原料の多結晶シリコンは不定形な小塊形状であるため、図２４に示すように、石英ルツボ９３に充填される小塊形状の多結晶シリコンｍ０は嵩張り、石英ルツボ９３に一度に大量に充填することは難しい。また、一回の単結晶引上げ毎に高価な新品の石英ルツボ９２を使用せねば成らず、引上げコストが上昇する。

【０００５】そこでコスト低減の方策として、図２５に示すようないわゆる原料追加チャージ方式が提案されている。この追加チャージ方式は単結晶製造装置１０１をゲートバルブ１０２により炉部材収納室１０３と単結晶収納部１０４に適宜仕切り可能にし、ゲートバルブ１０２の開放状態で単結晶引上げ初期に炉部材収納室１０３に配置された石英ルツボ１０５に小塊形状の多結晶シリコンｍ０を充填し、さらに、この小塊形状の多結晶シリコンｍ０とは別個にシリコン塊Ｍ０を、このシリコン塊Ｍ０に設けられた支持溝１１１に取付ワイヤ１０６を巻回し、この取付ワイヤ１０６を引上げ用ワイヤ１０７に結びつけ、引上げ用ワイヤ１０７に支持し（図２５（ａ））、小塊形状の多結晶シリコンｍ０を溶融させ石英ルツボ１０５の約８０％程度までシリコン融液Ｌ０を満たし（図２５（ｂ））、このシリコン融液Ｌ０とは別個に引上げ用ワイヤ１０７を降下させて、シリコン融液Ｌ０にシリコン塊Ｍ０を接触させて追加溶融させ（図２５（ｃ））、シリコン融液Ｌ０が石英ルツボ１０５のほぼ全体に満される。

【０００６】一方、取付ワイヤ１０６に支持された未溶融部を残して多結晶シリコン塊Ｍ０を溶融させた後、取付ワイヤ１０６を上昇させ、完全にゲートバルブ１０２を閉じ、ゲートバルブ１０２により仕切られた単結晶収納部１０４内で，シリコン塊の残部を支持した取付ワイヤ１０６と種結晶支持手段１０８とを交換して取付けし、この種結晶支持手段１０８に種結晶Ｓ０が取付けられる（図２５（ｄ））。

【０００７】しかる後、ゲートバルブ１０２を開放し、種結晶Ｓ０を石英ルツボ１０５中で溶融状態のシリコン融液Ｌ０に接触させて、種結晶Ｓ０の下部に種結晶Ｓ０と同じ結晶方位を有する単結晶Ｉｇ０を成長させ（図２５（ｅ））、石英ルツボ１０５中にはシリコン融液Ｌ０がほとんど残らない状態とする（図２５（ｆ））。

【０００８】上記の単結晶製造装置１０１を用いた半導体単結晶の製造方法によれば、図２４に示すような通常のＣＺ法の製造方法よりも石英ルツボ１個当たりのシリコン単結晶の生産量は増大する。

【０００９】しかし、この製造方法では、ヒータ１０９等が付勢された状態で単結晶製造装置１０１の稼働中に最低でも１回はゲートバルブ１０２を閉じて、炉部材収納室１０３と単結晶収納部１０４とを分離し、かつ、この単結晶収納部１０４を開放して未溶融部の多結晶シリコン塊Ｍ０を支持した取付ワイヤ１０６と種結晶支持手段１０８との取付けの交換を行い、さらに多結晶シリコン塊Ｍ０を支持した取付ワイヤ１０６の引上ワイヤ１０７への取付け、および種結晶支持手段１０８への種結晶Ｓ０の取付けを行わなければならず、単結晶収納部１０４は大気に曝される。大気に曝された単結晶収納部１０４を再度炉部材収納室１０３と連通させると、単結晶収納部１０４から塵埃などが落下し、単結晶Ｉｇ０の成長を阻害し単結晶化率（結晶欠陥が発生せず単結晶が得られる割合）を低減させる大きな要因になっている。また、ゲートバルブ１０２の開閉によるゲートバルブ室１１０からの塵埃などの落下も生じる。さらに、取付ワイヤ１０６にはシリコン塊の未融液部が残り不経済である。

【００１０】また、別のコスト低減の方策として、図２

６に示すようないわゆる原料のリチャージ方式がある。

【００１１】このリチャージ方式は単結晶製造装置１２１をゲートバルブ１２２により炉部材収納室１２３と単結晶収納部１２４に適宜仕切り可能にし、ゲートバルブ１２２の開放状態で単結晶Ｉｇ１を引上げて取出し、炉部材収納室１２３に配置された石英ルツボ１２５に溶融シリコンＬ１を残存させ（図２６（ａ））、次に、ゲートバルブ１２２により仕切られた単結晶収納部１２４内で種結晶支持手段１２６をシリコン塊Ｍ１に設けられた支持溝１２７に巻回された取付ワイヤ１２８に交換して引上げ用ワイヤ１２９に取付け（図２６（ｂ））、この取付ワイヤ１２８に取付けられた多結晶シリコン塊Ｍ１を降下させシリコン融液Ｌ１に接触させて溶融させ、シリコン融液Ｌ１にする（図２６（ｃ））。

【００１２】多結晶シリコン塊Ｍ１の溶融に因りシリコン融液Ｌ１は石英ルツボ１２５のほぼ全体に満され、一方、多結晶シリコン塊Ｍ１の未溶融部を支持した取付ワイヤ１２８を上昇させ、ゲートバルブ１２２を閉じ、ゲートバルブ１２２により仕切られた単結晶収納部１２４内で多結晶シリコン塊Ｍ１の未溶融部を支持した取付ワイヤ１２８と種結晶支持手段１２６とを交換して取付け、この種結晶支持手段１２６に種結晶Ｓ１が取付けられる（図２６（ｄ））。

【００１３】しかる後、ゲートバルブ１２２を開放し、種結晶Ｓ１を石英ルツボ１２５中で溶融状態の多結晶シリコンＭ１に接触させて、種結晶Ｓ１に単結晶Ｉｇ１を成長させる（図２６（ｅ））。

【００１４】しかし、この製造方法でも、ヒータ１３０等が付勢された状態で単結晶製造装置１２１の稼働中に２回はゲートバルブ１２２を閉じて、炉部材収納室１２３と単結晶収納部１２４とを分離し、かつこの単結晶収納部１２４を開放して、種結晶支持手段１２６と多結晶シリコン塊Ｍ１の未溶融部を支持した取付ワイヤ１２８の交換、および逆に新しいシリコン塊Ｍ１が支持された取付ワイヤ１２８と種結晶支持手段１２６の交換を行う必要があるため、単結晶収納部１２４は２回も大気に曝される。また、取付ワイヤ１２８にはシリコン塊の未溶融部が残り不経済である。

【００１５】従って、このリチャージ方式は追加チャージ方式に比べてさらに塵埃などの落下により炉部材収納室１２３を汚損し、単結晶Ｉｇ０の成長を阻害し単結晶化率を低減させる大きな要因となる虞があった。

【００１６】さらに、上述した追加チャージ方式、リチャージ方式とも引上げ装置内のガス置換を必要とするため、１回の引上げに要するサイクルタイムは通常のＣＺ法よりも長くなる問題点がある。

【００１７】

【発明が解決しようとする課題】そこで、半導体原料塊の供給時、半導体単結晶製造装置内を汚染することがなく、単結晶化率の向上が図れ、かつ１回の引上げに要するサイクルタイムも長くならず、さらに、半導体原料塊を未溶融部が残らず完全に溶融できる多結晶原料支持治具および種結晶ならびにこれを用いた単結晶の製造方法が要望されていた。

【００１８】本発明は上述した事情を考慮してなされたもので、半導体原料塊の供給時、半導体単結晶製造装置内を汚染することがなく、単結晶化率の向上が図れ、かつ１回の引上げに要するサイクルタイムも長くならず、さらに、半導体原料塊を未溶融部が残らず完全に溶融できる多結晶原料支持治具および種結晶ならびにこれを用いた単結晶の製造方法を提供することを目的とする。

【００１９】

【課題を解決するための手段】上記目的を達成するためになされた本願請求項１の発明は、上端に引上げ用ワイヤが取付けられ下端に種結晶が取付けられる取付部材と、この取付部材に設けられ半導体原料塊を支持する支持手段と、この支持手段と半導体原料塊との支持状態を解除する半導体製の動作制御手段とを有し、半導体原料塊を溶融させる途中で前記動作制御手段の溶融に因り、支持手段による半導体原料塊の支持を解除して、半導体原料塊を容器内に落下、溶融させることを特徴とする半導体原料塊支持治具であることを要旨としている。

【００２０】本願請求項２の発明では、上記支持手段は、取付部材に開閉動作可能に設けられ開動作または閉動作により半導体原料塊を挟むように支持する複数個の支持体で形成されていることを特徴とする請求項１に記載の半導体原料塊支持治具であることを要旨としている。

【００２１】本願請求項３の発明では、上記支持手段は、取付部材に開閉動作可能に設けられ、半導体原料塊を支持している状態では支持体間に種結晶を収納し、半導体原料塊の容器内への落下、溶融状態では種結晶を露出させていることを特徴とする請求項１または２に記載の半導体原料塊支持治具であることを要旨としている。

【００２２】本願請求項４の発明では、上記支持体は、一端に爪部が設けられ、他端に重りが取付けられた支持部材を、その中間部で取付部材に設けられた軸に回動自在に取付けたことを特徴とする請求項２または３に記載の半導体原料塊支持治具であることを要旨としている。

【００２３】本願請求項５の発明では、上記支持体は、動作した支持体の重りが種結晶の上方に位置して静止するように、偏倚した中間部で軸に取付けられていることを特徴とする請求項２ないし４のいずれか１項に記載の半導体原料塊支持治具であることを要旨としている。

【００２４】本願請求項６の発明では、上記爪部は、半導体原料塊の側面部に設けられた支持溝に係合することを特徴とする請求項２ないし５のいずれか１項に記載の半導体原料塊支持治具であることを要旨としている。

【００２５】本願請求項７の発明では、上記動作制御手段は、支持溝の位置よりも深く半導体原料塊の上部に断

面を横断して切込まれた落下用切欠部で形成されたことを特徴とする請求項1ないし6のいずれか1項に記載の半導体原料塊支持治具であることを要旨としている。

【0026】本願請求項8の発明では、上記落下用切欠部は、断面が楔形状または矩形形状であることを特徴とする請求項7に記載の半導体原料塊支持治具であることを要旨としている。

【0027】本願請求項9の発明では、上記動作制御手段は、支持部材に設けられた連結子間に橋設される固形半導体多結晶または単結晶であり、かつ、断面を横断し支持溝の位置よりも深く切込まれた切欠部内に収容されていることを特徴とする請求項2ないし8のいずれか1項に記載の半導体原料塊支持治具であることを要旨としている。

【0028】本願請求項10の発明は、上記支持手段は、取付部材に形成され、半導体原料塊に設けられた係合部に係合する支持部で形成され、この支持部はその断面積が順次増大するような末広形状に形成され、上記動作制御手段は半導体原料塊の上部に断面を横断して設けられた切欠部で形成され、上記種結晶は動作制御手段内に収納されており、半導体原料塊を溶融させる途中で半導体原料塊の溶融に因り半導体原料塊が分割されて支持部による半導体原料塊の支持が解除され、半導体原料塊を容器内に落下、溶融させることを特徴とする請求項1に記載の半導体原料塊支持治具であることを要旨としている。

【0029】本願請求項11の発明では、上記支持部は、球面部を有することを特徴とする請求項10に記載の半導体原料塊支持治具であることを要旨としている。

【0030】本願請求項12の発明では、上記支持部は、円錐体部で形成されていることを特徴とする請求項11に記載の半導体原料塊支持治具であることを要旨としている。

【0031】本願請求項13の発明では、上記支持部は、球面部が取付部材から分割されることを特徴とする請求項11に記載の半導体原料塊支持治具であることを要旨としている。

【0032】本願請求項14の発明では、上記支持部は、円錐体部が取付部材から分割されることを特徴とする請求項12に記載の半導体原料塊支持治具であることを要旨としている。

【0033】本願請求項15の発明は、半導体原料塊に設けられた収納部に収納され、半導体原料融液に接触させて単結晶を成長させる単結晶成長部と、この単結晶成長部の上方に設けられ、断面積が順次増大する末広形状の支持部とを具備し、この支持部は半導体原料塊に設けられ半導体原料塊の溶融に因り分割される動作制御手段に係合し、半導体原料塊を溶融させる途中で半導体原料塊の溶融に因り半導体原料塊が分割されて支持部による半導体原料塊の支持が解除され、半導体原料塊を容器内に落下、溶融させると共に、単結晶成長部を露出させることを特徴とする種結晶であることを要旨としている。

【0034】本願請求項16の発明では、上記支持部は、球面部を有することを特徴とする請求項15に記載の種結晶であることを要旨としている。

【0035】本願請求項17の発明では、上記支持部は、円錐体部で形成されていることを特徴とする請求項15に記載の種結晶であることを要旨としている。

【0036】本願請求項18の発明では、上記支持部は、離間して複数個設けられることを特徴とする請求項15ないし17のいずれか1項に記載の種結晶であることを要旨としている。

【0037】本願請求項19の発明は、容器内に収容された半導体原料融液に、引上げ用ワイヤに取付けられた種結晶を接触させて、種結晶から半導体単結晶を成長させる半導体単結晶の製造方法において、上端に引上げ用ワイヤが取付けられ下端に種結晶が取付けられる取付部材と、この取付部材に設けられ半導体原料塊を支持する支持手段と、この支持手段と半導体原料塊との支持状態を解除する半導体製の動作制御手段とを有する半導体原料塊支持治具により半導体原料塊を支持する工程と、この半導体原料塊を溶融させる途中で動作制御手段の溶融に因り支持手段との係合状態を解除して半導体原料塊を容器内に落下させ溶融させる工程と、前記容器内の半導体原料融液に前記種結晶を接触させて単結晶を成長させる工程とを有することを特徴とする半導体単結晶の製造方法であることを要旨としている。

【0038】本願請求項20の発明では、上記半導体原料塊支持治具に支持された半導体原料塊を溶融させる工程に先行する前工程として、予め容器内に半導体融液を収容させておく工程を有することを特徴とする請求項19に記載の半導体単結晶の製造方法であることを要旨としている。

【0039】本願請求項21の発明では、上記予め容器内に半導体融液を収容させておく工程は、半導体単結晶の製造の初期に容器内に半導体原料を溶融させる工程であることを特徴とする請求項20に記載の半導体単結晶の製造方法であることを要旨としている。

【0040】本願請求項22の発明では、上記予め容器内に半導体融液を収容させておく工程は、先行して行われる半導体単結晶の製造において半導体原料融液を残存させておく工程であることを特徴とする請求項19に記載の半導体単結晶の製造方法であることを要旨としている。

【0041】

【発明の実施の形態】以下、本発明に係わる多結晶原料支持治具およびと種結晶ならびにこれを用いた単結晶の製造方法について添付図面に基づき説明する。

【0042】図1に示すような本発明に係わる半導体単結晶の製造方法に用いられる単結晶製造装置、例えばC

Ｚ法による単結晶引上げ装置１は、炉部材収納室２とこの炉部材収納室２の上方に連接して設けられた単結晶収納部３とで形成されている。炉部材収納室２内にはヒータ４により加熱され黒鉛ルツボ５に内装された容器例えば石英ルツボ６が設けられており、この石英ルツボ６内で原料の多結晶が加熱溶融される。黒鉛ルツボ５は炉体７を貫通し、モータ（図示せず）に結合されて回転されるルツボ回転軸８に取付けられている。

【００４３】また、単結晶収納部３には昇降自在に設けられたワイヤ９の下端に本発明に係わる半導体原料塊支持治具１０が設けられている。

【００４４】図２ないし図４に示すように、半導体原料塊支持治具１０は、一端１１ａに引上げ用ワイヤ９が取付けられ他端１１ｂに種結晶Ｓが取付けられた取付部材１１と、この取付部材１１に設けられ半導体原料塊Ｍを支持する支持手段、例えば一対の支持体１２、１２と、この支持体１２、１２と半導体原料塊Ｍとの支持状態を解除する、例えば支持体１２、１２間に橋設された動作制御手段１３とを有している。

【００４５】支持体１２、１２は、一端に爪部１４、１４が設けられた支持部材１５、１５と、この支持部材１５、１５の回転軸１６、１６から内方に約３０°折曲して位置する他端に設けられた重り１７、１７と、支持部材１５、１５と平行に延伸し、爪部１８、１８が設けられた他の支持部材１９、１９とを有している。

【００４６】支持体１５、１５、１９、１９は、回転軸１６，１６を中心に回動するように、その中間部で取付部材１１に設けられ矩形形状に組立てられた軸受部材２０に回転軸１６、１６を介して回動自在に取付けられ、図５および図６に示すように、動作制御手段１３が溶融され支持体１２、１２が動作した状態で、支持部材１５、１５の重り１７、１７が種結晶Ｓの上方に位置して静止するように、偏倚した中間部で回転軸１６、１６に取付けられている。支持部材１５、１５、１９、１９の長さは単結晶引上げ時、単結晶収納部３の内径を考慮して決定されており、単結晶引上げ中爪部１４、１４、１８、１８が単結晶収納部３の壁面に当らないようになっている。また、各々の支持部材１５、１５に設けられた重り１７、１７は、軸受部材２０の対角線上に配設されており、各々の重り１７、１７の回動が干渉されないようになっている。

【００４７】爪部１４、１４、１８、１８は支持部材１５、１５、１９、１９から９０°折曲して形成されており、図２に示すように、支持体１２、１２による半導体原料塊Ｍの支持は、支持部材１５、１５、１９、１９に設けられた４個の爪部１４、１４、１８、１８を半導体原料塊Ｍの側面部に設けられた支持溝２１に係合することにより行われている。

【００４８】動作制御手段１３は、支持体１２、１２に設けられ平行に垂下する一対の連結子２２、２２が挿入される取付孔（図示せず）が設けられた例えば、Ｕ字形状の固形半導体多結晶製であり、上記のように一対の連結子２２、２２間に橋設され、かつ、半導体原料塊Ｍの上部にその断面を横断して設けられ、支持溝２１の位置よりも深く切込まれた矩形形状の切欠部２３内に収容されている。

【００４９】なお、種結晶Ｓの取付部材１１への取付けは、取付部材１１および種結晶Ｓに各々設けられた取付孔（図示せず）に係合ピン（図示せず）を挿入して行われる。

【００５０】次に、本発明に係わる半導体原料塊支持治具および半導体単結晶の製造方法を用いたいわゆる原料追加チャージ方式を説明する。

【００５１】図７は追加チャージ方式の半導体単結晶の製造工程図で、単結晶引上げ装置１の炉部材収納室２内に設置された石英ルツボ６に小塊形状の原料の多結晶シリコンｍを充填し、さらに単結晶収納部３のワイヤ９に取付けられた半導体原料塊支持治具１０の取付部材１１に種結晶Ｓを取付け、しかる後、図２ないし図４に示すように、半導体原料塊Ｍを垂直に保持しながら、種結晶Ｓを一対の支持体１２、１２間に収納し、かつ、一対の連結子２２、２２を切欠部２３に収納するように支持部材１５、１５、１９、１９を垂下し、平行にして爪部１４、１４、１８、１８を支持溝２１に係合し半導体原料塊Ｍを一対の支持体１２、１２で支持した後、切欠部２３内で一対の連結子２２、２２を動作制御手段１３の取付孔に挿入して、支持部材１５、１５、１９、１９の開放動作を抑え、半導体原料塊支持治具１０により半導体原料塊Ｍを支持する（図７（ａ））。

【００５２】次に、石英ルツボ６の外周に設けたヒータ４を付勢して、多結晶シリコンｍを完全に加熱溶融され、多結晶シリコン塊Ｍの溶融より先に予め石英ルツボ６の約８０％程度までシリコン融液Ｌを満す（図７（ｂ））。さらに、小塊形状の多結晶シリコンｍとは別個に用意し、既に単結晶収納部３に収納され半導体原料塊支持治具１０により支持された半導体原料塊Ｍを降下てシリコン融液Ｌに接触させ追加溶融させる。この半導体原料塊Ｍを溶融させる工程において、半導体原料塊Ｍは順次溶融されるが、図３および図４に示すように、溶融が切欠部２３に達し、さらに図５に示すように、Ｕ字形状の多結晶半導体の動作制御手段１３が溶融されると、重り１７、１７により生じる力により支持体１２、１２は開放動作して、半導体原料塊支持治具１０と半導体原料塊Ｍ（残部）との係合状態は解除され半導体原料塊Ｍは石英ガラスルツボ６内に落下し溶融される。従って、半導体原料塊Ｍは全て融液Ｌ中に落下して溶融される。

【００５３】半導体原料塊Ｍの溶融が完了するとシリコン融液Ｌは石英ルツボ６のほぼ全体に満される。一方、支持体１２、１２が開放動作すると、図６に示すよう

に、爪部１４、１４、１８、１８は上方に跳ね上がり、重り１７、１７が下方になる。しかし、支持部材１５、１５は偏倚した位置で取付部材１１に回動自在に取付けられているので、単結晶Ｓが最下位に露出し、引上げ時の種結晶の機能を果たせる状態になる（図7（ｄ））。

【００５４】しかる後、単結晶引上げ装置１内を単結晶引上げ条件に適合させ、種結晶Ｓを石英ルツボ６中で溶融状態のシリコン融液Ｌに接触させて、種結晶Ｓに単結晶Ｉｇを成長させる（図7（ｅ））。

【００５５】さらに単結晶インゴットＩｇを成長させて引上げを完了させるが、石英ルツボ６内には再使用可能な溶融シリコンＬは残存していない（図7（ｅ））。

【００５６】上述した本発明に係わる半導体単結晶の製造方法によれば、原料半導体塊Ｍを支持し種結晶Ｓが取付けられた原料半導体支持治具１０を用いることにより、種結晶支持手段と原料半導体塊支持治具の交換のために、炉体８または単結晶収納部３を開放する必要がなく、原料半導体塊Ｍを追加原料として溶融できて、石英ルツボ６に汚染のない十分なシリコン融液Ｌの供給が可能となり、一度に大容量のシリコン単結晶Ｉｇを高単結晶化率で引上げることができる。

【００５７】また、単結晶引上げ装置１を炉部材収納室２と単結晶収納部３とに適宜仕切るゲートバルブも不要となり、ゲートバルブの開閉に伴い単結晶収納部３から塵埃などが落下して、溶融シリコン融液Ｌが汚染されることもなくなり、単結晶Ｉｇの成長が阻害されることもなく、単結晶化率の高率化も図れる。

【００５８】さらに、引上げ工程における最初の小塊形状の原料半導体ｍと原料半導体塊Ｍとを同時に装填する時、および引上げられた単結晶インゴットＩｇの取出し時以外に、一連の工程中に炉体７または単結晶収納部３を開放する必要がないため、ガス置換も不必要であり、１回の引上げに要するサイクルタイムも通常のＣＺ法よりも長くなることがない。

【００５９】原料半導体塊Ｍは残部を半導体原料塊支持治具に未溶融部を残すことなく、全て溶融させることができるので経済的である。

【００６０】次に、半導体原料塊支持治具および半導体単結晶の製造方法を用いた他の実施形態であるいわゆるリチャージ方式を説明する。上述した実施形態と同一部分には同一符号を付して説明する。

【００６１】図8はリチャージ方式の半導体単結晶の製造工程を示すもので、成長した単結晶Ｉｇを引上げ、一方、石英ルツボ６に溶融シリコンＬを残存させると共にヒータ４の付勢を継続して溶融シリコンＬの溶融状態を保つ（図8（ａ））。

【００６２】次に、単結晶収納部３に設けられたゲートバルブ３１を閉じて単結晶Ｉｇを取出すと共に、上述した実施形態で用い図7に示したと同様の構造を有し、ワイヤ９に取付けられた本発明に係わる半導体原料塊支持治具１０の取付部材１１に種結晶Ｓを取付ける。しかる後、図2ないし図4に示すように、半導体原料塊Ｍを垂直に保持し、一対の連結子２２、２２が切欠部２３に収納されるように支持部材１５、１５、１９、１９を垂下し、平行にして爪部１４、１４、１８、１８を支持溝２１に係合させ半導体原料塊Ｍを一対の支持体１２、１２で支持した後、切欠部２３内で一対の連結子２２、２２を動作制御手段１３の取付孔に挿入して、支持部材１５、１５、１９、１９の開放動作を抑え、半導体原料塊支持治具１０により半導体原料塊Ｍを支持する（図8（ｂ））。

【００６３】次に、ゲートバルブ３１を開いて多結晶シリコン塊Ｍをシリコン融液ｍに浸して溶融させる（図8（ｃ））。この半導体原料塊Ｍを溶融させる工程において、半導体原料塊Ｍは順次溶融されるが、図3および図4に示すように、溶融が切欠部２３に達し、さらに図5に示すように、Ｕ字形状の多結晶半導体の動作制御手段１３が溶融されると、重り１７、１７によって生じる力により支持体１２、１２は開放動作して、半導体原料塊支持治具１０と半導体原料塊Ｍ（残部）との係合状態は解除され半導体原料塊Ｍは容器内に落下し溶融される。従って、半導体原料塊Ｍは全て融液Ｌ中に落下して溶融される。

【００６４】半導体原料塊Ｍの溶融が完了するとシリコン融液Ｌは石英ルツボ６のほぼ全体に満され、一方、支持体１２、１２が開放動作すると、図6に示すように、単結晶Ｓが最下位に露出し、引上げ時の種結晶の機能を果たせる状態になる（図8（ｄ））。

【００６５】しかる後、単結晶引上げ装置１ａ内を単結晶引上げ条件に適合させ、種結晶Ｓを石英ルツボ６中で溶融状態のシリコン融液Ｌに接触させて、種結晶Ｓに単結晶Ｉｇを成長させる（図8（ｅ））。

【００６６】さらに単結晶インゴットＩｇを成長させて引上げを完了させるが、石英ルツボ６等に耐久力があり、さらに新規の単結晶の引上げを行なう場合には、再使用可能な溶融シリコンＬを残存させる（図8（ａ））。

【００６７】本実施形態の半導体単結晶の製造方法によれば、原料半導体塊Ｍを支持し種結晶Ｓが取付けられた原料半導体支持治具１０を用いることにより、種結晶支持手段と原料半導体塊支持治具の交換のために、単結晶収納部３を開放は１回で済む。従って、シリコン単結晶Ｉｇの高単結晶化率で引上げることが可能となり、半導体単結晶の製造コスト低減化に寄与する。このため、従来のリチャージ法では少なくとも２回であったゲートバルブの開閉回数を低減させ、開閉に伴う炉内への汚染のおそれを低減しつつ十分なシリコン融液の供給が可能となり、シリコン単結晶を高単結晶化率で引上げることができる。原料半導体塊Ｍは残部を半導体原料塊支持治具に未溶融部を残すことなく、全て溶融させることができ

るので経済的である。

【0068】次に、本発明に係わる半導体原料塊支持治具の他の実施形態について説明する。上述した実施形態と同一部分には同一符号を付して説明する。

【0069】図9ないし図12に示すように、半導体原料塊支持治具41は、一端42aに引上げ用ワイヤ9が取付けられ他端42bに種結晶Sが取付けられた取付部材42と、この取付部材42に設けられ半導体原料塊Mを支持する支持手段、例えば一対の支持体43、43と、この支持体43、43間に配設され半導体原料塊Mに設けられた動作制御手段44とを有している。

【0070】各々の支持体43、43は、一端に2個の爪部45、46が設けられた支持部材47、47と、この支持部材47、47の回転軸48、48から外方に約30°折曲して位置する他端に設けられた重り49、49とを有している。

【0071】支持部材47、47は、回転軸48、48を中心に回動するように、その中間部で取付部材42に設けられ矩形形状の軸受部材50に回転軸48、48を介して回動自在に取付けられ、図11および図12に示すように、動作制御手段44が溶融され支持体43、43が動作した状態で、支持部材47、47の重り49、49が種結晶Sの上方に位置して静止するように、偏倚した中間部で回転軸48、48に取付けられている。

【0072】重り49、49は支持部材47、47の爪部45、45、46、46側を閉動作させるものであり、取付部材42に取付けられた矩形形状の軸受部材50の対角線上に配設されており、各々の重り49、49の回動が干渉されないようになっている。

【0073】爪部45、45、46、46は支持部材47、47から90°折曲して形成されており、半導体原料塊Mの支持は、4個の爪部45、45、46、46を支持溝51に係合することにより行われている。

【0074】動作制御手段44は半導体原料塊Mの上部に設けられ、中心線cに沿って断面を横断して切欠され、支持溝51の位置よりも深く切込まれた先細の楔形状の切欠部52により形成されている。従って、図13および図14に示すように、半導体原料塊Mの溶融が進行し、溶融面が動作制御手段44の下端に達すると、支持部材47、47の爪部45、45、46、46により閉方向の力により半導体原料塊M（残部）は切欠部52を縮小する方向に押圧され、支持溝51と爪部45、45、46、46の係合が外れて、支持部材47、47による半導体原料塊Mの支持が解除され、半導体原料塊M（残部）は完全に落下するようになっている。

【0075】このとき、図10および図12に示すように、支持溝51と爪部45、45、46、46の係合は動作制御手段44を形成する切欠部52の中心軸線cまたはこの中心軸線dと直交する線上から外した位置で行なわれるようになっているので、より確実に支持溝51と爪部45、45、46、46の係合が外れ易くなっている。

【0076】なお、動作制御手段44を形成する切欠部52は、断面が楔形状に限らず、矩形形状であってもよい。

【0077】本実施形態の原料半導体支持治具41を原料追加チャージ方式の単結晶の製造方法に用いれば、種結晶支持手段と原料半導体塊支持治具の交換のために、炉体8または単結晶収納部3を開放する必要がなく、原料半導体塊Mを追加原料として溶融でき、石英ルツボ6に汚染のない十分なシリコン融液Lの供給が可能となり、一度に大容量のシリコン単結晶Igを高単結晶化率で引上げることができる。

【0078】また、単結晶引上げ装置1をゲートバルブにより炉部材収納室2と単結晶収納部3とに適宜仕切るゲートバルブも不要となり、また、ゲートバルブの開閉に伴い単結晶収納部3から塵埃などが落下して、溶融シリコン融液Lが汚染されることもなくなり、単結晶Igの成長が阻害されることもなく、単結晶化率の高率化も図れる。

【0079】さらに、引上げ工程における最初の小塊形状の原料半導体mと原料半導体塊Mとを同時に装填する時、および引上げられた単結晶インゴットIgの取出し時以外に、一連の工程中に炉体7または単結晶収納部3を開放する必要がないため、ガス置換も不必要であり、1回の引上げに要するサイクルタイムも通常のCZ法よりも長くなることがない。

【0080】原料半導体塊Mは残部を半導体原料塊支持治具に残すことなく、全て溶融させることができるので経済的である。

【0081】また、リチャージ方式に用いれば、原料半導体塊Mを支持し種結晶Sが取付けられた原料半導体支持治具41を用いることにより、種結晶支持手段と原料半導体塊支持治具の交換のために、単結晶収納部3の開放は1回で済む。従って、シリコン単結晶Igを高単結晶化率で引上げることが可能となり、半導体単結晶の製造コスト低減化に寄与する。このため、従来のリチャージ法では少なくとも2回であったゲートバルブの開閉回数を低減させ、開閉に伴う炉内への汚染のおそれを低減しつつ十分なシリコン融液の供給が可能となり、シリコン単結晶を高単結晶化率で引上げることができる。

【0082】さらに、本発明に係わる半導体原料塊支持治具の他の実施形態について説明する。上述した第1の実施形態と同一部分には同一符号を付して説明する。

【0083】図15および図16に示すように、半導体原料塊支持治具61は、タングステンやモリブデン等の金属または金属化合物もしくは炭素または炭素化合物等からなり、その一端62aに引上げ用ワイヤ9が取付けられ他端62bに種結晶Sが取付けられた取付部材62と、この取付部材62に設けられ半導体原料塊Mを支持

する支持手段、例えば半導体原料塊Mに設けられた係合部６３に係合する支持部６４と、半導体原料塊Mに設けられた動作制御手段６５とを有している。

【００８４】支持部６４は、取付部材６２から膨出し断面積が順次増大するような末広形状、例えば円錐体の一部を有する形状に形成されている。

【００８５】動作制御手段６５は、半導体原料塊Mの上部に設けられ、かつ、中心線ｃに沿って切欠された細長のU字形状切欠部６６と、この切欠部６６の上部に設けられ、断面形状が取付部材６２の円錐体部を有する形状と同一の末広形状をなす係合部６３とで形成されている。U字形状切欠部６６は取付部材６２に取付けられた種結晶Sが収納されるに十分な深さを有している。

【００８６】従って、図１７および図１８に示すように、半導体原料塊Mの溶融が進行し、溶融面が動作制御手段６５の下端部６５ｄに達すると、半導体原料塊M（残部）には自重により切欠部６６を拡大する方向に力が働き、係合部６３と支持部６４の係合が外れて、原料半導体塊支持治具６１による半導体原料塊Mの支持が解除され、半導体原料塊M（残部）は完全に落下するようになっている。図１９に示すように露出した種結晶Sを融液に接触させて、単結晶Ｉｇを成長させる。

【００８７】なお、図２０に示すように、支持部７１は、円錐体の一部形状を利用したものに限らず、球面部を有するものでもよく、また、図２１（ａ）〜（ｃ）に示すように、支持部７２は取付部材７３から分割可能に形成されていてもよい。支持部７１が球面部で形成されていれば、係合部６３の断面形状が如何なる形状であっても、係合部６３と支持部７１の係合が外れ易い。また、支持部７２を分割方式にすれば、支持部７２が劣化した場合には、この支持部７２のみを交換すれば再使用が可能である。

【００８８】さらに、支持部７１、７２を半導体原料と同じ材質で形成すえば、原料塊Mと支持部７１、７２とが接触することによる汚染を防ぐことができ好適である。

【００８９】本実施形態の原料半導体支持治具６１を原料追加チャージ方式の単結晶の製造方法に用いれば、上述した実施形態の原料半導体支持治具と同様に、石英ルツボ６に汚染のない十分なシリコン融液Lの供給が可能となり、一度に大容量のシリコン単結晶Ｉｇを高単結晶化率で引上げることができる。また、ゲートバルブの開閉に伴い単結晶収納部３から塵埃などが落下して、溶融シリコン融液Lが汚染されることもなくなり、単結晶Ｉｇの成長が阻害されることもなく、単結晶化率の高率化も図れる。

【００９０】さらに、ガス置換も不必要であり、１回の引上げに要するサイクルタイムも通常のＣＺ法よりも長くなることがなく、また、原料半導体塊Mは残部を半導体原料塊支持治具に未溶融部を残すことなく、全て溶融させることができるので経済的である。さらに、支持部６４を取付部材６２に膨出して形成したので、可動部分がなく構造が簡単で経済的な半導体原料塊支持治具を提供することができる。また、支持部７２を分割方式にすれば、支持部７２が劣化した場合には、この支持部７２のみを交換することで半導体原料塊支持治具６１全体を交換することなく、元に復することができ経済的である。さらに、単結晶引上げ完了毎に汚染除去のための化学エッチングを行なう必要がある場合には、種結晶Sのみを行なえばよく、半導体原料塊支持治具６１が薬品によりエッチングされることもなく、長寿命化が実現できる。

【００９１】また、リチャージ方式に用いれば、上述した実施形態の原料半導体支持治具と同様に、シリコン単結晶Ｉｇを高単結晶化率で引上げることが可能となり、半導体単結晶の製造コスト低減化に寄与する。さらに、開閉に伴う炉内への汚染のおそれを低減しつつ十分なシリコン融液の供給が可能となり、シリコン単結晶を高単結晶化率で引上げることができる。

【００９２】さらに、本発明に係わる種結晶について説明する。

【００９３】図２２および図２３に示すように、本発明に係わる種結晶Ｓ１は、下部に単結晶成長部Ｓ１ａと、この単結晶成長部Ｓ１ａの上方に設けられ、半導体原料塊Mに設けられた動作制御手段８１に係合し、かつ、断面積が順次増大するような末広形状、例えば球面部で形成された支持部８２とを有し、単結晶の成長と半導体原料塊Mを支持する２機能を有している。

【００９４】動作制御手段８１は、半導体原料塊Mの上部に設けられた係合孔８３とこの係合孔８３に連通し、かつ、この係合孔８３の直径よりも大きな直径を有し、半導体原料塊Mを長手方向に貫通する貫通孔８４と、支持部８２が係合孔８３と係合状態にあるとき、単結晶成長部Ｓ１ａが達する位置よりも下まで達する分割溝８５とを有している。この分割溝８５は半導体原料塊Mの断面を横断して形成されており、半導体原料塊Mがこの分割溝８５まで溶融されると、半導体原料塊M（残部）は分割するようになっている。

【００９５】半導体原料塊Mの単結晶Ｓ１への取付けは、単結晶成長部Ｓ１ａを下にした状態で種結晶Ｓ１を貫通孔８４に貫通させ、支持部８２を係合孔８３に係合させた後、種結晶Ｓ１を取付部材（図示せず）に固定して行なう。

【００９６】従って、図２２に示すように、半導体原料塊Mの溶融時、半導体原料塊Mの溶融が進行し、溶融面１が半導体原料塊Mの分割溝８５の下端に達すると、半導体原料塊M（残部）には自重により係合孔８３を拡大する方向に力が働き、係合孔８３と支持部８２の係合が外れて、種結晶Ｓ１による半導体原料塊Mの支持が解除され、半導体原料塊M（残部）は完全に落下するように

なっている。半導体原料塊Mの落下により、種結晶S１（単結晶成長部S１ａ）は露出する。

【００９７】本実施形態の種結晶S１を原料追加チャージ方式の単結晶の製造方法に用いれば、上述した第一の実施形態の原料半導体支持治具と同様に、石英ルツボ６に汚染のない十分なシリコン融液Lの供給が可能となり、一度に大容量のシリコン単結晶Ｉｇを高単結晶化率で引上げることができる。また、ゲートバルブの開閉に伴い単結晶収納部３から塵埃などが落下して、溶融シリコン融液Lが汚染されることもなくなり、単結晶Ｉｇの成長が阻害されることもなく、単結晶化率の高率化も図れる。さらに、ガス置換も不必要であり、１回の引上げに要するサイクルタイムも通常のＣＺ法よりも長くなることがなく、また、原料半導体塊Mは残部を半導体原料塊支持治具に残すことなく、全て溶融させることができるので経済的である。さらに、支持部８２を単結晶S１に一体的に膨出して形成したので、可動部分がなく構造が簡単で経済的な半導体原料塊支持治具として使用できる。

【００９８】また、リチャージ方式に用いれば、上述した実施形態の原料半導体支持治具と同様に、シリコン単結晶Ｉｇの高単結晶化率で引上げることが可能となり、半導体単結晶の製造コスト低減化に寄与する。さらに、開閉に伴う炉内への汚染のおそれを低減しつつ十分なシリコン融液の供給が可能となり、シリコン単結晶を高単結晶化率で引上げることができる。

【００９９】なお、支持部８２は、円錐体の一部形状を利用したものに限らず、球面部を有するものでもよい。

【０１００】また、図２５に示すように、断面積が順次増大するような末広形状、例えば球面部で形成された支持部８６を離間して複数個設けると共に、原料半導体塊Mの上部に断面を横断する矩形形状の切欠部８７を設け、かつ、この切欠部８７の上方に平行に係合溝条８８を設け、さらに、係合溝条８８に連通する係合孔８９を設け、この係合孔８９に支持部８６を係合させるようにしてもよい。

【０１０１】支持部８６が球面部に形成されていれば、係合孔８９の断面形状が如何なる形状であっても、係合孔８９と支持部８６の係合が外れ易い。また、支持部８６を離間して複数個設ければ、複数回に追加溶融にも容易に対応でき便利である。

【０１０２】

【実施例】試験１：図３に示すような半導体原料塊支持治具を用いて、直径１２７ｍｍ、重量１５ｋｇ、長さ６００ｍｍの棒状シリコン多結晶を溶融させ、従来例と比較した。

【０１０３】結果：実施例は棒状多結晶原料を１５ｋｇ全て溶融させることができた。また、棒状多結晶原料の溶融が完了した後、支持体が種結晶よりも上方に上がるため、棒状多結晶原料支持治具と種結晶とを交換する作業をせずに、引続き単結晶の育成に移行することができた。

【０１０４】これに対して、ワイヤ巻き付けによる支持方法の従来例では、棒状多結晶原料を約１２ｋｇまで溶融できたが、残りの約３ｋｇ分は溶融させることができなかった。また、棒状多結晶原料を溶融させた後、種結晶を取付ける為の作業に約１．５時間を必要とした.

試験２：図１１に示すような半導体原料塊支持治具を用いて、直径１２７ｍｍ、重量１５ｋｇ、長さ６００ｍｍの棒状シリコン多結晶を溶融させ、従来例と比較した。

【０１０５】結果：上述した試験１と同様の結果を得た。

【０１０６】試験３：図１６に示すような半導体原料塊支持治具を用いて、直径１４０ｍｍ、重量２７ｋｇ、長さ約８６０ｍｍの棒状シリコン多結晶を溶融させ、従来例と比較した。

【０１０７】結果：実施例は棒状多結晶原料を２７ｋｇ全て溶融させることができた。また、棒状多結晶原料の溶融が完了した後、支持体が種結晶よりも上方に上がるため、棒状多結晶原料支持治具と種結晶とを交換する作業をせずに、引続き単結晶の育成に移行することができた。

【０１０８】これに対して、ワイヤ巻き付けによる支持方法の従来例では、棒状多結晶原料を約２５ｋｇまで溶融できたが、残りの約２ｋｇ分は溶融させることができなかった。また、棒状多結晶原料を溶融させた後、種結晶を取付ける為の作業に約１．５時間を必要とした.

試験４：図２３に示すような種結晶を用い、棒状シリコン多結晶を原料追加チャージ方式により溶融させて、単結晶の製造を行った。

【０１０９】結果：棒状多結晶原料支持治具と種結晶との交換作業が必要でなく、従来例に比べて約６０分単結晶引上げ時間を短縮することができた。

【０１１０】

【発明の効果】本発明に係わる半導体原料塊支持治具および種結晶ならびにこれを用いた単結晶の製造方法によれば、半導体原料塊の供給時、半導体単結晶製造装置内を汚染することがなく、単結晶化率の向上が図れ、かつ１回の引上げに要するサイクルタイムも長くならず、さらに、半導体原料塊を完全に溶融できる多結晶原料支持治具およびと種結晶ならびにこれを用いた単結晶の製造方法を提供することができる。

【０１１１】即ち、種結晶が取付けられた支持手段により半導体原料塊を支持し、半導体原料塊の溶融途中で支持状態を解除する半導体製の動作制御手段の溶融に因り、半導体原料塊の支持を解除して、半導体原料塊を容器内に落下、溶融させるので、本発明に係わる原料半導体支持治具を原料追加チャージ方式の単結晶の製造方法に用いれば、種結晶支持手段と原料半導体塊支持治具の交換のために、炉体または単結晶収納部を開放する必要

がなく、原料半導体塊を追加原料として溶融できて、石英ルツボに汚染のない十分なシリコン融液の供給が可能となり、一度に大容量のシリコン単結晶を高単結晶化率で引上げることができる。また、単結晶引上げ装置をゲートバルブにより炉部材収納室と単結晶収納部とを適宜仕切るゲートバルブも不要となり、また、ゲートバルブの開閉に伴い単結晶収納部から塵埃などが落下して、溶融シリコン融液が汚染されることもなくなり、単結晶の成長が阻害されることもなく、単結晶化率の高率化も図れる。

【0112】さらに、引上げ工程における最初の小塊形状の原料半導体と原料半導体塊とを同時に装填する時、および引上げられた単結晶インゴットの取出し時以外に、一連の工程中に炉体または単結晶収納部を開放する必要がないため、ガス置換も不必要であり、1回の引上げに要するサイクルタイムも通常のCZ法よりも長くなることがない。また、原料半導体塊は残部を半導体原料塊支持治具に残すことなく、全て溶融させることができるので経済的である。

【0113】また、リチャージ方式に用いれば、原料半導体塊を支持し種結晶が取付けられた原料半導体支持治具を用いることにより、種結晶支持手段と原料半導体塊支持治具の交換のために、単結晶収納部の開放は1回で済む。従って、シリコン単結晶の高単結晶化率で引上げることが可能となり、半導体単結晶の製造コスト低減化に寄与する。このため、従来のリチャージ法では少なくとも2回であったゲートバルブの開閉回数を低減させ、開閉に伴う炉内への汚染のおそれを低減しつつ十分なシリコン融液の供給が可能となり、シリコン単結晶を高単結晶化率で引上げることができる。

【0114】また、支持手段は取付部材に開閉動作可能に設けられ開動作または閉動作により半導体原料塊を挟むように支持する複数個の支持体で形成されているので、半導体原料塊を確実に支持できると共に、支持体間に種結晶を収納することができ、省スペース化が図れる。

【0115】また、支持体は一端に爪部が設けられ、他端に重りが取付けられた支持部材を、その中間部で取付部材に設けられた回転軸に回動自在に取付けたので、半導体原料塊を確実に支持できると共に、重りの作用で支持体により自動的に半導体原料塊の支持解除を行うことができる。

【0116】また、支持体は動作した支持体の重りが種結晶の上方に位置して静止するように偏倚した中間部で回転軸に取付けたので、種結晶を確実に最下に位置させることができる。

【0117】また、爪部が半導体原料塊の側面部に設けられた支持溝に係合することにより、簡単な形状で容易かつ確実に原料半導体塊を半導体原料塊支持治具で支持、解放することができる。

【0118】また、動作制御手段は支持溝の位置よりも深く半導体原料塊の上部に断面を横断して切込まれた落下用切欠部で形成されているので、半導体原料塊の溶融途中で確実に半導体原料塊を落下、溶融させることができる。

【0119】また、落下用切欠部は断面が楔形状または矩形形状であるので、簡単な構造にもかかわらず、半導体原料塊を確実に落下、溶融させることができる。

【0120】また、動作制御手段は支持部材に設けられた連結子間に橋設される固形半導体多結晶または単結晶であり、かつ、支持溝の位置よりも深く切込まれた切欠部内に収容されているので、半導体原料塊の溶融途中で確実に半導体原料塊を落下、溶融させることができ、さらに半導体製であるので、不純物にはならず、単結晶化率を低下させることもない。

【0121】また、支持手段を形成する支持部は、断面積が順次増大するような末広形状に形成され、動作制御手段は半導体原料塊の上部に断面を横断して設けられた切欠部で形成され、種結晶は動作制御手段内に収納されているので、可動部分がなく構造が簡単で経済的な半導体原料塊支持治具を提供することができる。さらに、単結晶引上げ完了毎に汚染除去のための化学エッチングを行なう必要がある場合には、種結晶のみを行なえばよく、半導体原料塊支持治具が薬品によりエッチングされることもなく、長寿命化が実現できる。

【0122】また、支持部は球面部を有しているので、係合部の断面形状が如何なる形状であっても、係合部と支持部の係合が外れ易く、確実に半導体原料塊を落下させることができる。

【0123】また、支持部は円錐体部で形成されているので、係合部と支持部の係合が外れ易く、確実に半導体原料塊を落下させることができる。

【0124】また、支持部は球面部が取付部材から分割されているので、支持部が劣化した場合には、この支持部のみを交換することで半導体原料塊支持治具全体を交換することなく、元に復することができ経済的である。

【0125】また、支持部は円錐体部が取付部材から分割されているので、支持部が劣化した場合には、この支持部のみを交換することで半導体原料塊支持治具全体を交換することなく、元に復することができ経済的である。

【0126】また、種結晶は半導体原料塊に設けられた収納部に収納され、半導体原料融液に接触させて単結晶が成長させる単結晶成長部と、この単結晶成長部の上方に設けられ、断面積が順次増大する末広形状の支持部とを具備するので、原料追加チャージ方式またはリチャージ方式の単結晶の製造方法に用いれば、石英ルツボに汚染のない十分なシリコン融液の供給が可能となり、一度に大容量のシリコン単結晶を高単結晶化率で引上げることができる。さらに、ガス置換も不必要であり、1回の

引上げに要するサイクルタイムも通常のＣＺ法よりも長くなることがなく、また、原料半導体塊は残部を半導体原料塊支持治具に残すことなく、全て溶融させることができるので経済的である。さらに、支持部を種結晶に一体的に膨出して形成したので、可動部分がなく構造が簡単で経済的な半導体原料塊支持治具として使用できる。

【０１２７】また、シリコン単結晶の支持部は球面部を有するので、係合部の断面形状が如何なる形状であっても、係合部と支持部の係合が外れ易く、確実に半導体原料塊を落下させることができる。

【０１２８】また、シリコン単結晶の支持部は円錐体部で形成されているので、係合部と支持部の係合が外れ易く、確実に半導体原料塊を落下させることができる。

【０１２９】また、支持部は離間して複数個設けられているので、複数回の追加溶融にも容易に対応でき便利である。

【０１３０】また、上端に引上げ用ワイヤが取付けられ下端に種結晶が取付けられる取付部材と、この取付部材に設けられ半導体原料塊を支持する支持手段と、この支持手段と半導体原料塊との支持状態を解除する半導体製の動作制御手段とを有する半導体原料塊支持治具により半導体原料塊を支持する工程を有する半導体単結晶の製造方法を原料追加チャージ方式の単結晶の製造方法に用いれば、種結晶支持手段と原料半導体塊支持治具の交換のために、炉体または単結晶収納部を開放する必要がなく、原料半導体塊を追加原料として溶融できて、石英ルツボに汚染のない十分なシリコン融液の供給が可能となり、一度に大容量のシリコン単結晶を高単結晶化率で引上げることができる。また、単結晶引上げ装置をゲートバルブにより炉部材収納室と単結晶収納部とを適宜仕切るゲートバルブも不要となり、また、ゲートバルブの開閉に伴い単結晶収納部から塵埃などが落下して、溶融シリコン融液が汚染されることもなくなり、単結晶の成長が阻害されることもなく、単結晶化率の高率化も図れる。

【０１３１】さらに、引上げ工程における最初の小塊形状の原料半導体と原料半導体塊とを同時に装填する時、および引上げられた単結晶インゴットの取出し時以外に、一連の工程中に炉体または単結晶収納部を開放する必要がないため、ガス置換も不必要であり、１回の引上げに要するサイクルタイムも通常のＣＺ法よりも長くなることがない。また、原料半導体塊は残部を半導体原料塊支持治具に残すことなく、全て溶融させることができるので経済的である。

【０１３２】また、リチャージ方式に用いれば、原料半導体塊を支持し種結晶が取付けられた原料半導体支持治具を用いることにより、種結晶支持手段と原料半導体塊支持治具の交換のために、単結晶収納部の開放は１回で済む。従って、シリコン単結晶の高単結晶化率で引上げることが可能となり、半導体単結晶の製造コスト低減化に寄与する。このため、従来のリチャージ法では少なくとも２回であったゲートバルブの開閉回数を低減させ、開閉に伴う炉内への汚染のおそれを低減しつつ十分なシリコン融液の供給が可能となり、シリコン単結晶を高単結晶化率で引上げることができる。

【図面の簡単な説明】

【図１】本発明に係わる半導体単結晶の製造方法の一実施形態を示す説明図。

【図２】本発明に係わる半導体原料塊支持治具の一実施形態による半導体原料塊の支持状態を示し、（ａ）はその平面図、（ｂ）は（ａ）のＣ－Ｃ’矢視断面図。

【図３】本発明に係わる半導体原料塊支持治具の一実施形態の正面図。

【図４】本発明に係わる半導体原料塊支持治具の一実施形態の側面図。

【図５】本発明に係わる半導体原料塊支持治具の一実施形態の動作状態を示す説明図。

【図６】本発明に係わる半導体原料塊支持治具の一実施形態の動作状態を示す説明図。

【図７】（ａ）～（ｆ）は各々本発明に係わる半導体単結晶の製造方法を原料追加チャージ方式の単結晶の製造方法に用いた一実施形態の製造工程図。

【図８】（ａ）～（ｅ）は各々本発明に係わる半導体単結晶の製造方法をリチャージ方式の単結晶の製造方法に用いた一実施形態の製造工程図。

【図９】本発明に係わる半導体原料塊支持治具の他の実施形態の平面図。

【図１０】本発明に係わる半導体原料塊支持治具の他の実施形態の半導体原料塊の支持状態を示し、（ａ）はその平面図、（ｂ）はその縦断面図。

【図１１】本発明に係わる半導体原料塊支持治具の他の実施形態の正面図。

【図１２】本発明に係わる半導体原料塊支持治具の他の実施形態の側面図。

【図１３】本発明に係わる半導体原料塊支持治具の他の実施形態の動作状態を示す説明図。

【図１４】本発明に係わる半導体原料塊支持治具の他の実施形態の動作状態を示す説明図。

【図１５】本発明に係わる半導体原料塊支持治具の他の実施形態の正面図。

【図１６】本発明に係わる半導体原料塊支持治具の他の実施形態の支持状態を示し、（ａ）はその平面図、（ｂ）はその縦断面図。

【図１７】本発明に係わる半導体原料塊支持治具の他の実施形態の動作状態を示す説明図。

【図１８】本発明に係わる半導体原料塊支持治具の他の実施形態の動作状態を示す説明図。

【図１９】本発明に係わる半導体原料塊支持治具の他の実施形態を用いた単結晶引上げ状態の説明図。

【図２０】本発明に係わる半導体原料塊支持治具の他の

実施形態の変形例を示す説明図。

【図21】(a)〜(c)は本発明に係わる半導体原料塊支持治具の他の実施形態の変形例を示す説明図。

【図22】本発明に係わる半導体原料塊支持治具の他の実施形態の断面図。

【図23】本発明に係わる半導体原料塊支持治具の他の実施形態の変形例を示す断面図。

【図24】従来の半導体単結晶の製造方法の単結晶の製造方法。

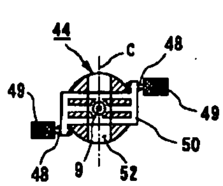
【図25】(a)〜(f)は各々従来の原料追加チャージ方式の単結晶の製造方法の製造工程図。

【図26】(a)〜(e)は各々従来のリチャージ方式の単結晶の製造方法の製造工程図。

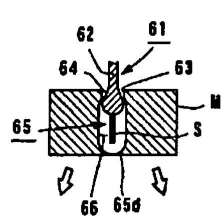
【符号の説明】

1　単結晶製造装置
2　炉部材収納室
3　単結晶収納部
4　ヒータ
5　黒鉛ルツボ
6　石英ルツボ
7　炉体
8　ルツボ回転軸
9　引上げ用ワイヤ
10　半導体原料塊支持治具
11　取付部材
11a　一端
11b　他端
12　支持体
13　動作制御手段
14　爪部
15　支持部材
16　回転軸
17　重り
18　爪部
19　支持部材
20　軸受部材
21　支持溝
22　連結子
23　切欠部
M　半導体原料塊(多結晶シリコン塊)
S　種結晶
41　半導体原料塊支持治具
42　取付部材
42a　一端
42b　他端
43　支持体
44　動作制御手段
45　爪部
46　爪部
47　支持部材
48　回転軸
49　重り
50　軸受部材
51　支持溝
52　切欠部
61　半導体原料塊支持治具
62　取付部材
62a　一端
62b　他端
63　係合部
64　支持部
65　動作制御手段
65d　下端部
66　切欠部
71　支持部
72　支持部
81　動作制御手段
82　支持部
83　係合孔
84　貫通孔
85　分割溝
86　支持部
87　切欠部
88　係合溝条
89　係合孔
S1　種結晶
S1a　単結晶成長部

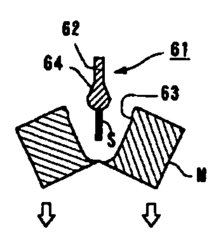
【図9】



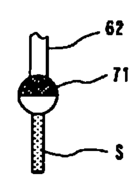
【図17】



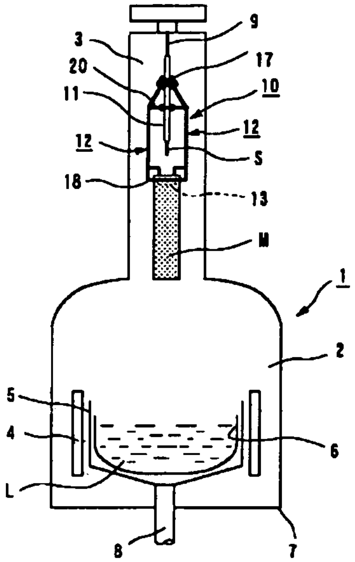
【図18】



【図20】

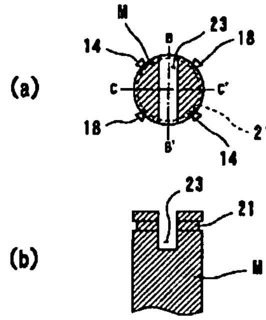


【図1】

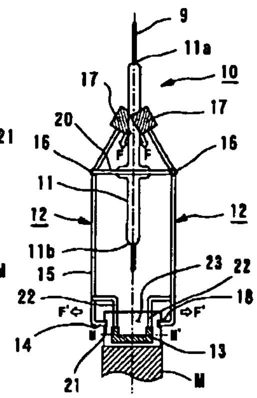


1:単結晶製造装置
2:炉部材収納室
3:単結晶収納部
4:ヒータ
6:石英ルツボ
10:半導体原料塊支持治具
11:取付部材
13:動作制御手段
M:半導体原料塊(多結晶シリコン塊)
S:種結晶

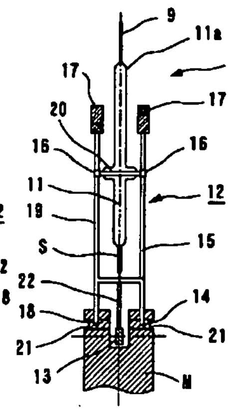
【図2】



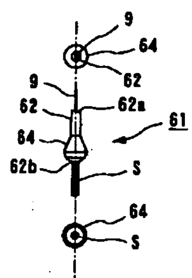
【図3】



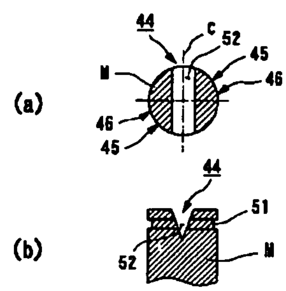
【図4】



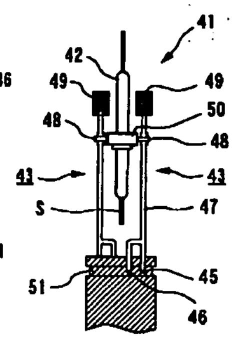
【図15】



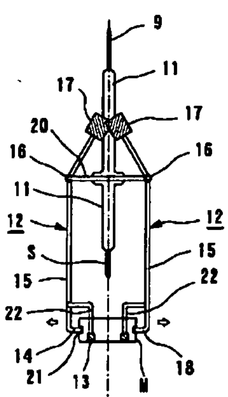
【図10】



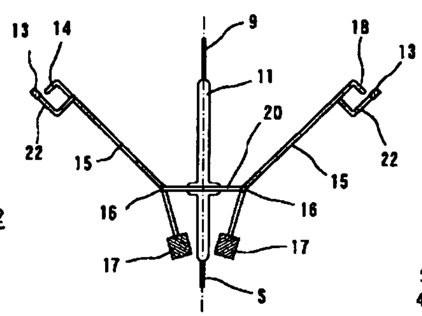
【図12】



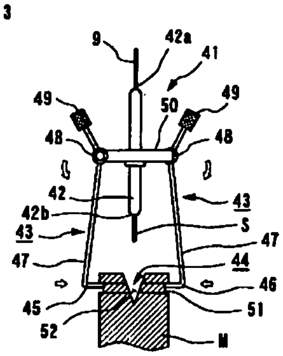
【図5】



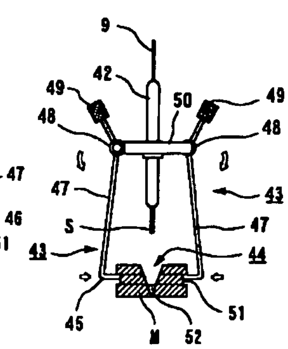
【図6】



【図11】



【図13】



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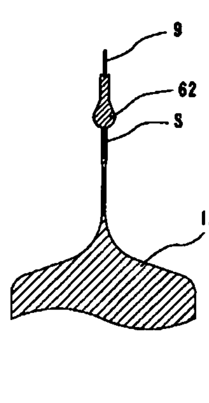

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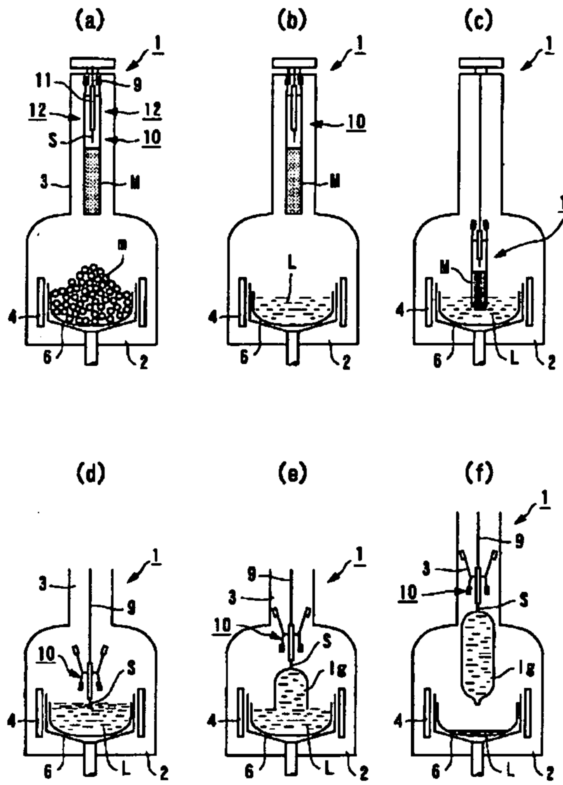

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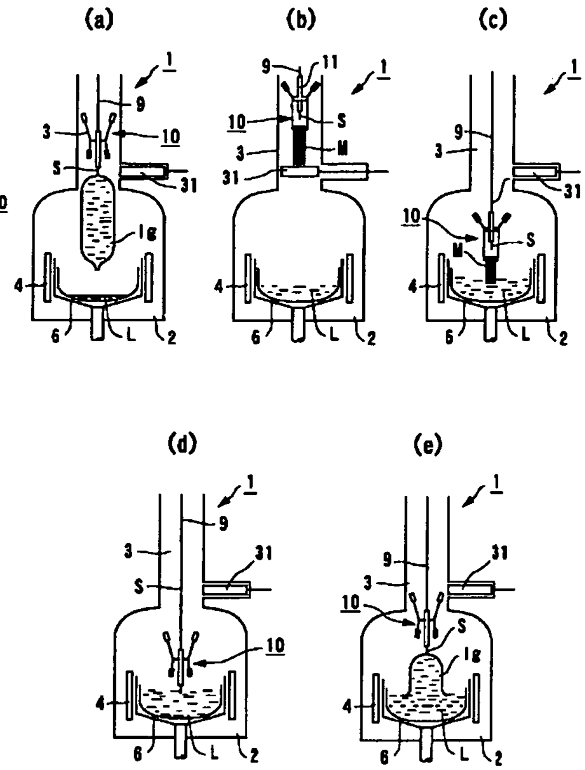

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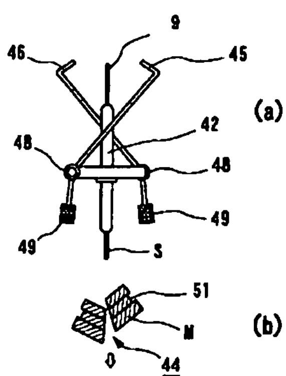

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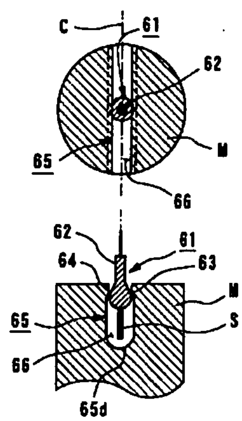

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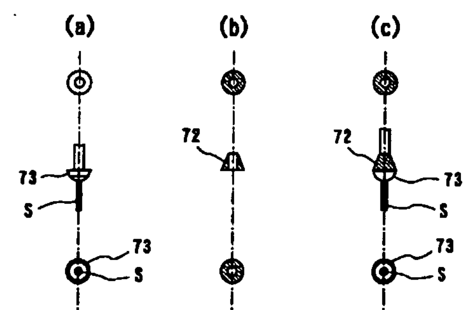

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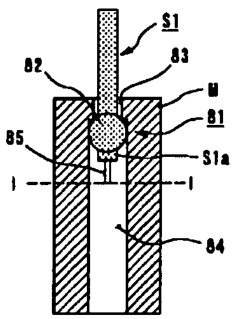

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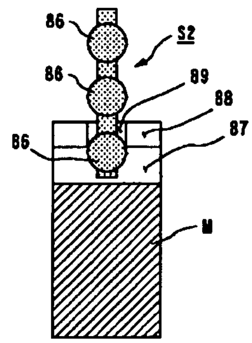

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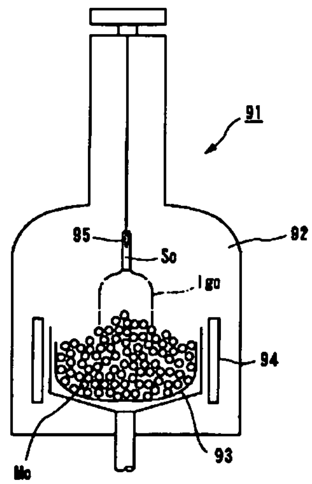

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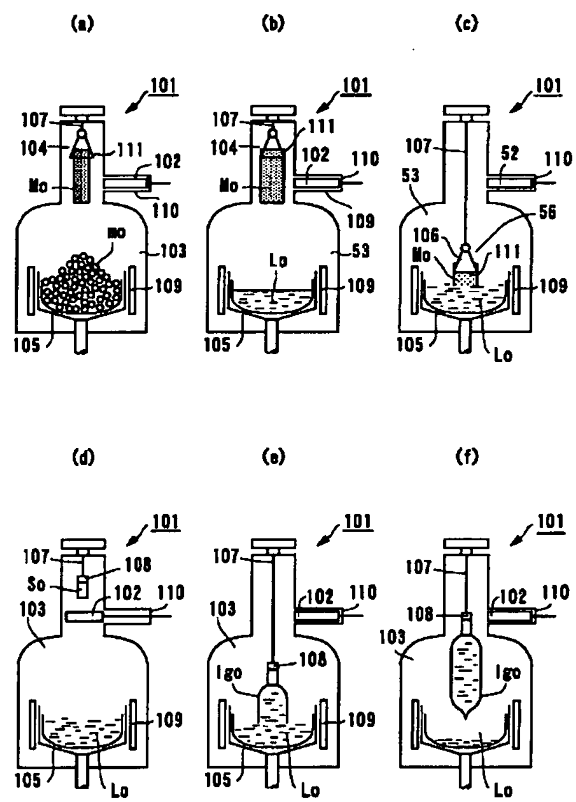

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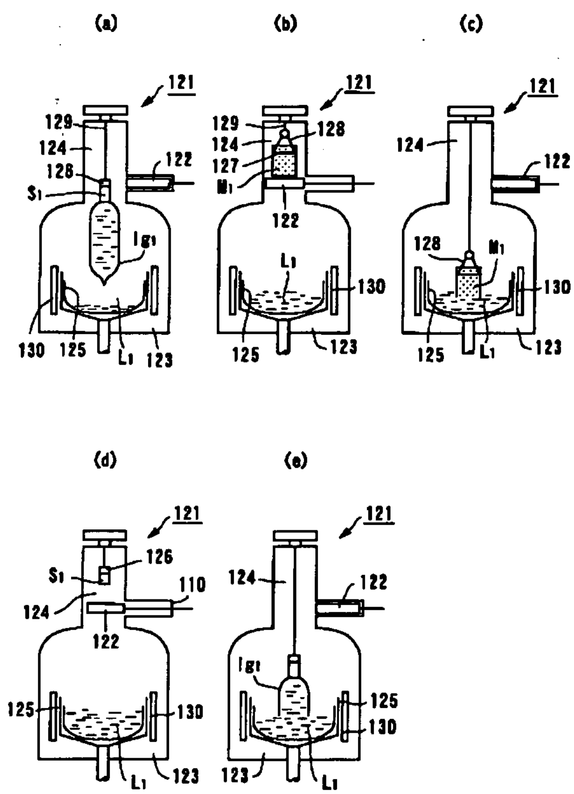

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